DOCUMENT RESUME

ED 038 257

RE 002 457

AUTHOR	Holmes, Jack A.; Singer, Harry
TITLE	Speed and Power of Reading in High School.
INSTITUTION	Office of Education (DHEW), Washington, D.C.
REPORT NO	CRM-14; OE-30016
PUB DATE	66
NOTE	185p.
AVAILABLE FROM	Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (FS5.230:30016, $0.70)
EDRS PRICE	EDRS Price MF-$0.75 HC Not Available from EDRS.
DESCRIPTORS	Factor Analysis, High School Students, Models, *Reading Comprehension, Reading Development, *Reading Processes, *Reading Research, Reading Skills, *Reading Speed

ABSTRACT

The major focus of this investigation was concerned with discovering differences in the substrata-factor patterns which underlie speed and/or power of reading in various known groups: boys versus girls, bright versus dull, fast versus slow readers, and powerful versus nonpowerful readers. Subjects were 211 boys and 189 girls selected at random from the summer school population of the University of California Demonstration Secondary School. The 54 independent variables consisted of group-administered paper and pencil tests selected or constructed for the purpose of assessing areas which might bear a meaningful relationship to the criteria. Main areas assessed for the independent variables included mental abilities, linguistic abilities, verbal perception, listening comprehension, music ability and appreciation, academic attitudes and habits, interests, emotional-social problems, and chronological age. A substrata-factor analysis, a centroid-factor analysis, and separate treatment of the total group were performed. Results indicated that while reading ability is a composite of speed and power, beyond certain basic skills, different students may draw upon different factors to achieve reading success. Charts, tables, appendixes, and references are included. (WB)

SPEED
and
POWER
OF READING IN HIGH SCHOOL

SPEED AND POWER OF READING IN HIGH SCHOOL

cooperative - research

The research reported herein was performed pursuant to a contract (Nos. 538 and 538A) with the Office of Education, U.S. Department of Health, Education, and Welfare, under the provisions of Public Law 83-531, the Cooperative Research Program.

Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

ED038257

OE-30016
Cooperative Research
Monograph No. 14

SPEED and POWER OF READING IN HIGH SCHOOL

by

Jack A. Holmes and Harry Singer
University of California

U.S. DEPARTMENT OF HEALTH, EDUCATION
& WELFARE
OFFICE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

RE002 457

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Office of Education

A publication of the
BUREAU OF EDUCATIONAL RESEARCH
AND DEVELOPMENT
RALPH C. M. FLYNT, *Associate Commissioner*
E. GLENN FEATHERSTON, *Deputy Associate Commissioner*
Division of Educational Research
FRANCIS A. J. IANNI, *Director*

Superintendent of Documents Catalog No. FS 5.230:30016

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1966

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 70 cents

FOREWORD

In recent years the teaching of reading at all educational levels has received much attention both from the educational community and from the general public. Any changes in the teaching of reading must necessarily stem from the results of research. Currently, completed research is being scrutinized, and new concepts and theories are being investigated. The complex nature of the reading process has been recognized, and new approaches and theories have been advanced. Dr. Holmes' project represents not only theory construction but also experimental research. Educational change will occur when results of research, such as that conducted by Dr. Holmes and reported here, are implemented in the classroom.

Ralph C. M. Flynt,
Associate Commissioner for
Educational Research and Development.

ACKNOWLEDGMENTS

Long fascinated by the possibility of probing the workings of the mind in the reading process, in 1953 I designed and launched this study, with the aid of a faculty research grant from the University of California. From the same source, several such grants followed, each being used to advance the study another step toward its ultimate goal.

In 1959, the Office of Education, U.S. Department of Health, Education, and Welfare, contracted to underwrite the most expensive phase of the study—the statistical reduction and analyses of the data on high-speed digital computers—to be carried out under the auspices of the University of California. Support of this Cooperative Research Project was continued in the form of a second contract in order that certain unexpected, yet technically fundamental, questions which had arisen regarding statistical methodology could be resolved.

Finally, a university changeover from the 701 to the 704 digital computer toward the end of the project necessitated the rewriting of many of our programs. The executive program developed for the 704 digital computer to check the results of the present study became a basic data reduction program for a subsequent longitudinal study in reading that is now being pursued under the direction of the undersigned with the support of a substantial research grant from the Carnegie Corporation of New York. This program is now available to research workers wishing to do substrata-factor analyses similar to those reported here. The program, thanks to the support of the Office of Education, Cooperative Research Project No. 2011, has now also been written for the 7094 digital computer.

During the test construction and selection stage of the project, I drew heavily upon the services of Prof. Frank Laycock, chairman, Department of Education, Oberlin College, Ohio, and Martin Kling, assistant professor, Rutgers University, N.J. I am indebted also to Dr. John Caffrey—now director of research, Palo Alto Unified School District, California—for the highly efficient way in which he coordinated his crew of 10 test administrators.

For their careful work in doublechecking all test scores, collated listings, and preliminary statistical calculations, I owe a debt of gratitude to Donald Green, associate professor, Emory University, Georgia; Jean Kerrick, assistant professor, University of California, Los Angeles; Jim Yandell, M.D., and Fred Rosenthal, M.D.; and Dr. Martin Kling.

I am sincerely grateful, too, to Evelyn Fix, professor of statistics, University of California, Berkeley, and to Walter Stellwagen, associate professor, Michigan State University, East Lansing, for their work as statistical consultants.

To Charles Perkins, Pamela Mayall, Emylu Gray, Gloria Penrose, Dorene Feldman, Ethel Merell, Punnee (Kiangsiri) Buddhari, Charuwan Thirawat, Shirley Potter, Joy Hussey, Jack Neuhaus and his staff, and Penny Gee, also go my sincere thanks for the many ways in which they contributed to this project.

To my wife, Florence C. Holmes, goes my profound appreciation for her special understanding and invaluable practical help.

JACK A. HOLMES,
Professor and Principal Investigator,
University of California, Berkeley.

CONTENTS

Page
Foreword III
Acknowledgments v

SECTION I: THEORY AND RELATED RESEARCH

Chapter I. Theory and Problem 3
  The Substrata-Factor Theory of Reading 3
  The Problem 7
Chapter II. A Review of Related Research 8

SECTION II: SAMPLE, TESTS, AND METHODOLOGY

Chapter III. The Subjects 17
Chapter IV. The Tests and Their Reliability 19
  Tests Used in Assessing *Dependent* Variables 19
  Tests Used in Assessing *Independent* Variables 20
  Psychometric Characteristics of Instruments Used 28
Chapter V. Statistical Methodology of the Substrata-Factor Analysis 31

SECTION III: THE SUBSTRATA-FACTOR ANALYSES

Chapter VI. A Substrata-Factor Analytic Study of Speed and Power of Reading for the Total Sample of High School Students 39
  Introduction 39
  Part I. Substrata Analysis for Speed of Reading: Total Sample 39
  Part II. Substrata Analysis for Power of Reading: Total Sample 66

Page

Chapter VII. A Comparative Substrata Analytic Study on Speed and Power of Reading for High School Boys vs. Girls 79

Introduction 79
Part I. Comparative Substrata Analyses for Speed of Reading: Boys vs. Girls 83
Part II. Comparative Substrata Analyses for Power of Reading: Boys vs. Girls 92

Chapter VIII. A Comparative Substrata Analytic Study on Speed and Power of Reading for High School Students Earning "High" vs. "Low" Scores on the Verbal Ability Scale of the PMA Test 102

Introduction 102
Part I. Comparative Substrata Analyses for Speed of Reading: Bright vs. Dull 102
Part II. Comparative Substrata Analyses for Power of Reading: Bright vs. Dull 104

Chapter IX. A Comparative Substrata Analytic Study on Speed of Reading for Known-Groups of Fast vs. Slow Readers 110

Introduction 110
Comparative Substrata Analyses for Speed of Reading: Fast vs. Slow 111

Chapter X. A Comparative Substrata Analytic Study on Power of Reading for Powerful vs. Nonpowerful Readers 117

Introduction 117
Cooperant Abilities of Powerful vs. Nonpowerful Readers... 118
Comparative Substrata Analyses for Power of Reading: Powerful vs. Nonpowerful 122

SECTION IV: THE CENTROID FACTOR ANALYSES

Page

Chapter XI. A Centroid Factor Analytic Study of Reading Abilities for the Total Group of High School Students 133

The Problem and Related Research 133
Summary of Related Research 133
A Centroid Factor Analysis of the Correlation Matrix for the Total Sample 134
Summary 144

Chapter XII. A Comparative Centroid Factor Analytic Study of Known-Groups 146

Introduction 146
Procedure 146
Results 146
Identification and Interpretation of Factors 147
Centroid Factor Structure of Speed of Reading 148
Centroid Factor Structure of Power of Reading 150
Summary of Centroid Factor Analyses of Total and Known-Groups 151

SECTION V: SUMMARY, CONCLUSIONS, AND IMPLICATIONS

Chapter XIII. Summary, Conclusions, and Implications 155

Theory and Rationale of the Experiment 155
Subjects 156
The Tests and Their Reliability 156
General Conclusions and Implications 158
Statistical Methodology of the Substrata-Factor Analysis 159
Results 160
Implications 165

APPENDIXES

A. Discussion of Basic Assumptions 177
B. References 181

Tables

Page

1. Sample classified according to grade and sex 17
2. Psychometric characteristics of instruments used in assessing dependent and independent variables 29
3. Mean and standard deviation on each variable for total sample, $N=400$ 40
4. Correlation matrix for the total high school sample, $N=400$ 42
5. Substrata analysis of total sample yielding accounted-for variance in Speed of Reading 57
6. Substrata analysis of total sample yielding accounted-for variance in Level I substrata factors underlying Speed 60
7. Substrata analysis of total sample yielding accounted-for variance in Level II substrata factors underlying Speed 63
8. Substrata analysis of total sample yielding accounted-for variance in Power of Reading 68
9. Substrata analysis of total sample yielding accounted-for variance in Level I substrata factors underlying Power 70
10. Substrata analysis of total sample yielding accounted-for variance in Level II substrata factors underlying Power 72
11. Comparison of means and standard deviations for boys and girls on dependent and independent variables 80
12. Comparison of zero-order coefficients of correlation of independent variables with Speed of Reading for boys and girls 84
13. Comparative analyses of boys vs. girls yielding accounted-for variance in Speed of Reading 86
14. Comparison of zero-order coefficients of correlation of independent variables with Power of Reading for boys and girls 93
15. Comparative analyses of boys vs. girls yielding accounted-for variance in Power of Reading 95
16. Comparative analyses of boys vs. girls yielding accounted-for variance in Level I substrata factors underlying Power 96
17. Comparison of zero-order coefficients of correlation of independent variables with Power of Reading for bright vs. dull sample 105
18. Comparison of means and standard deviations for fast vs. slow readers on dependent and independent variables 112
19. Comparison of means and standard deviations for powerful vs. nonpowerful readers on dependent and independent variables 120
20. Comparison of zero-order coefficients of correlation of independent variables with Power of Reading for powerful vs. nonpowerful readers 123
21. Comparative analyses of powerful vs. nonpowerful readers yielding accounted-for variance in Power of Reading 125
22. Loadings on Varimax rotated centroid factors for total group, $N=400$ 138

Tables—Continued

Page

23. Centroid factor loadings for Speed and Power of Reading 145
24. Summary of centroid factors with percent of common variance accounted for in the matrix of each known-group 147
25. Loadings of Speed and Power of Reading for each known-group on each of the identified factors 149
26. Comparative distributions of variance in centroid and substrata factors accounting for Speed of Reading (N=400) 166
27. Comparative distributions of variance in centroid and substrata factors accounting for Power of Reading (N=400) 168

Figures

1. Flowchart for the tasks involved in the reading act, with breakdown for underlying factors 10
2. Flowchart to show the results of the substrata analysis of Speed and Power of Reading at the fourth-grade level 12
3. Schematic diagram with generalized notation of a substrata analysis through three levels 34
4. Concentric flowchart for Speed of Reading for total sample of 400 high school students (a) 61
5. Concentric flowchart for Speed of Reading for total sample of 400 high school students (b) 66
6. Concentric flowchart for Power of Reading for total sample of 400 high school students (a) 76
7. Concentric flowchart for Power of Reading for total sample of 400 high school students (b) 77
8. Profile comparison of cooperant abilities, interests, and problems manifested by the 211 boys and 189 girls in total sample of 400 82
9. Flowchart for Speed of Reading for 211 high school boys 90
10. Flowchart for Speed of Reading for 189 high school girls 91
11. Flowchart for Power of Reading for 211 high school boys 99
12. Flowchart for Power of Reading for 189 high school girls 100
13. Flowchart for Speed of Reading for 108 "bright" high school students 103
14. Flowchart for Speed of Reading for 108 "dull" high school students 103
15. Flowchart for Power of Reading for 108 "bright" high school students 107
16. Flowchart for Power of Reading for 108 "dull" high school students 108
17. Profile comparison of cooperant abilities, interests, and problems manifested by the 108 fastest and 108 slowest readers in the total sample of 400 114
18. Flowchart for Speed of Reading for 108 "fastest" high school students 115

Figures—Continued

Page

19. Flowchart for Speed of Reading for 108 "slowest" high school students 115

20. Profile comparison of cooperant abilities, interests, and problems manifested by the 108 most powerful and 108 least powerful readers in total sample of 400 119

21. Flowchart for Power of Reading for the 108 most powerful readers 126

22. Flowchart for Power of Reading for the 108 nonpowerful readers 127

23. Paradigm for analyses for comparing centroid factors in all known-groups 148

24. Concentric flowchart for Speed of Reading for total sample of 400 high school students (c) 161

25. Concentric flowchart for Power of Reading for total sample of 400 high school students (c) 162

26. Model illustrating umbellating nature of lines of support for substrata factors underlying Power of Reading at the high school level 170

SECTION I

THEORY AND RELATED RESEARCH

Chapter I. Theory and Problem

The Substrata-Factor Theory of Reading[1]

In essence, the Substrata-Factor Theory holds that, normally, reading is an audiovisual verbal processing-skill of symbolic reasoning, sustained by the interfacilitation of an intricate hierarchy of substrata factors that have been mobilized as a psychological working-system and pressed into service in accordance with the purposes of the reader (Holmes, 1948, 1953, 1954, 1957, 1959, 1961).

Substrata factors are thought of as neurological memory systems composed of smaller subsystems of the brain containing various kinds of information, such as auditory, visual, and kinesthetic associations which in a cultural milieu bestow a sense of reality upon symbolically represented thought units. Such systems of subsystems gain an interfacilitation, in Hebb's (1949) sense, when their mobilized cell-assemblies fire in phase. By this means, appropriate, but diverse subsets of information, learned under different circumstances at different times, and therefore, stored in different parts of the brain, can be brought simultaneously into awareness when triggered by appropriate symbols on the printed page. These substrata factors are dynamically and functionally tied together in a working-system. As the efficiency of the neurointerfacilitation of the reading working-system increases, the effectiveness of the child's reading correspondingly increases. Such diverse substrata factors initially become associated into a particular working-system by the psychocatalytic action of what the Theory hypothesizes as "mobilizers." Mobilizers, then, may work at several levels.

More will be said about substrata factors under "Discussion of Basic Assumptions" in appendix A.

Mobilizers are psychologically defined as the focal points of deep-seated value systems, the fundamental ideas that the individual holds of himself and his developing relationship to his environment. As conative tendencies with or without conscious awareness, mobilizing neuromechanisms function to select from one's repertoire of subabilities those which will maximize one's chances of solving a specific problem and forwarding the realization of self-fulfillment in general.

---

[1] Much of the material in this chapter was presented in an address before the Fifth Annual Conference of the International Reading Association, New York, May 1960, and was subsequently published in *New Frontiers in Reading—International Reading Association, Conference Proceedings*; Vol. 5, 1960, p. 115-121.

Mobilizers play their major role as the fundamental driving value systems from which spring the many and specific attitudes and anxieties[2] which a person holds toward the purpose and worth of (*a*) life and death, (*b*) the social and physical nature of the universe, and (*c*) the self's expanding personality. Consequent patterns of behavior are directed by such value-attitudes. Neurologically, mobilizers may be thought of as controlling the electrochemical biases in the brain's scanning-search mechanism that govern which cell-assemblies shall be selected and momentarily tied into a particular neural pattern or working-system of communication. Thus, mobilizers function at all levels. At first, they function to form what might be termed microsystems of closely related information; these microsystems are combined into subsystems of more diverse yet still related information which might be identified as substrata factors. These substrata factors, in turn, may then be integrated into functional hierarchies or working systems which themselves may be organized into even more comprehensive working systems.

A *working-system* may be described as a dynamic set of subabilities which have been mobilized for the purpose of solving a particular problem. Neurologically, a working-system is conceptualized as a nerve-net pattern in the brain, functionally linking together the various substrata factors into a cerebral communications system.

The Theory maintains that the relative power of a total working-system is dependent upon the logical order and substantive content of the material stored in each of the substrata factors. Some interesting ways of looking at both intra- and inter-individual likenesses and differences follow from this premise. For instance, it is hypothesized that an individual will solve the same problem at different times in his life by using different working-systems. Moreover, different individuals may perform the same task with equal success by drawing upon different sets of subabilities. In other words, there is more than one way to solve an intellectual problem.

The Theory postulates that the pattern of substrata factors in a child's reading hierarchy will undergo a *gradient shift*[3] as he matures in reading. Advancing through the grades, a child increases his proficiency over a succession of newly learned subskills. Consequently, the substrata-factor patterns which underlie his speed and power of reading will also tend to change. Furthermore, this reorganization in the structure of his hierarchy will reflect the interaction and impact of the biochemical and neurophysiological factors of growth and development; the psychoeducational factors of learning; the nature, clarity, and sequential organization (breadth and depth) of the material studied; the methods by which the child has been taught to think about what he reads; and especially, his changing value systems. This hypothetical construct (i.e., expanding working-systems of substrata factors) broadens our insight into the dynamics by which individual differences may develop. Two children, for instance, may read quite differently not only because one child has more and better information stored in this or that particular substrata factor, but also because, for reading, one child has a working-system that is superior to that of the other.

---

[2] The theory holds that, without values, there can be no anxieties. Furthermore, other things remaining constant, the intensity of an anxiety is directly proportional to the strength of the value threatened.

[3] Experiments, by the senior author and his staff, supported by a 3-year grant from the Carnegie Corporation of New York, are currently being conducted at the Institute of Human Development, University of California at Berkeley, to test hypotheses derived from this aspect of the Theory.

What a child knows depends upon the repertoire of *information* stored in his cell-assemblies; but how he thinks and how he reasons with what he knows depends, first, upon the number and nature of his genetically determined neuroconfigurations; and second, upon the number, nature, and flexibility of the functional-configurations, or working-systems, into which he can efficiently organize his mental repertoire of information. Pedagogically speaking, a child's reasoning process is determined by the way in which facts, concepts, attitudes, interests, abilities, etc., are psychologically superimposed upon his basic neuroconfigurations.

Other things being equal, then, individual differences in the ability to reason about what is being read (that is, to manipulate mentally the inflow of new ideas so that they bear a meaningful relationship to what one has already learned) *depend both upon the essential nature of the stored information and the associative logic of the conceptualizing-activity-of-perceptual-process stimulated within the brain by the meaningfulness of the sequential input of information at the time of presentation and reception.* To reason creatively is a more complicated process (Holmes, 1961).

In the field of psychoeducation the Substrata-Factor Theory rejects the strict one-directional "cause and effect" hypothesis that has been so fruitful in classical physics. Instead, the Theory embraces the hypothesis that for the *individual* there is a mutual and reciprocal cause-and-effect relationship among the covert and overt responses made during the reading act, the cognitive manipulation of the substrata-factor content, and the perception of the socially intrinsic meaningfulness of the symbolic notations in the task-stimuli (Holmes, 1954). *Mutual-and-reciprocal causation* may be thought of as the "relative impact and support (not necessarily equal in both directions)," which factor A gives to B, C, D . . . N and B, C, D . . . N to A, when A is the more complex or more difficult ability (Holmes, 1954). The improvement of a relevant substrata factor results in an improvement of reading ability, and likewise, participation in the reading act results not only in an increase in the interfacilitating efficiency of the working-system, but also an increase in the content of the separate substrata factors and the perceptual discrimination of the symbols on the printed page.

Maruyama (1960) has recently given this notion a more generalized and elegant expression:

> Though multilateral mutual simultaneous causal relationships were implicit in the classical concepts of equilibrium in chemical processes, mutual inductance in electricity, homeostasis in biology, oscillatory circuit in radio engineering, "vicious circle" in economy, stability and instability in the evolution theory, etc., it took the impact of cybernetics, automatic control engineering and servomechanisms to make it explicit, amenable to rigorous mathematical treatment, and respectable as a scientific principle.

Maruyama also stressed the importance of the *initial kick* phenomenon in the "mutual-and-reciprocal causation" hypothesis (Holmes, 1954):

> Myrdal (1957) further points out the importance of the direction of the initial kick, which determines the direction of the subsequent deviation amplification. In underdeveloped countries not free market, but state interference and planning are essential, which can give a kick to a favorable direction of economic growth. The resulting development (output) will be far greater than the initial kick (input) due to the amplification effect of the mutual causation. This process of self-amplification has a profound significance for the philosophy of causality. This process makes it possible that dissimilar developments may take place from similar backgrounds due to small, possibly imperceptible differences in the initial kick. . . . This amounts to saying that "very similar initial conditions may produce entirely different developments."
>
> (Maruyama, 1960).

Hence, in the Substrata-Factor Theory of Reading, the *servomechanistic and interfacilitating aspects* of a working-system take into consideration the long-term effects of such "initial kick" differentials, i.e., teaching the child phonics prior to a look-say vocabulary may result in a different reading ability than teaching the child a look-say vocabulary prior to phonics, when, in fact, the amount and kinds of things taught are identical in the two overall programs. It is the *sequential input* of information that gives a different structural configuration to the cerebral communications systems and thus results in a different working-system, a different learning product.

The Problem

First, a representative sample of 400 high school students was analyzed to determine the patterns of substrata factors which underlie Speed and Power of Reading in the general high school population. Second, from this sample known-groups were drawn, and each was analyzed to determine the substratra-factor pattern underlying its ability to read with speed and/or power. Furthermore, in order to gain as much insight as possible into the nature of the substrata factors, profile and centroid factor analyses were made for the various groups.

This project was a further investigation of the Substrata-Factor Theory, and was designed to test two hypotheses in the following known-groups:

a. Total Sample
b. Boys vs. Girls
c. Bright vs. Dull
d. Fast vs. Slow Readers
e. Powerful vs. Nonpowerful Readers

1. The *major hypothesis* is that different known-groups will mobilize different substrata-factor hierarchies for the purpose of reading with speed and/or power; i.e., there is more than one way to solve an intellectual problem.

2. The *minor hypothesis* is that a student must learn to read by learning to integrate that characteristic hierarchy or "working-system" of substrata factors which will maximize the use of his strong abilities and minimize the use of his weak ones.

3. Beyond the testing of the above hypotheses, there is expected to accrue from the study a body of precise and important information on the very nature of the substrata factors which underlie the ability of high school students to read with speed and power—and this information is not dependent upon the validity of the hypotheses!

4. The experimental design places individuals who are alike on certain criteria into known-groups. A statistical analysis of each group is made to obtain a best estimate of the general pattern of abilities which underlies speed and/or power of reading. Such a pattern of abilities, of course, characterizes the mean, or theoretically most representative, individual for each group.

Chapter II. A Review of Related Research

Reviews of the literature in the field of reading (Holmes, 1948, 1953, 1954; Gilbert and Holmes, 1955; Bower and Holmes, 1959; Singer, 1960; Holmes and Singer, 1964) reveal no other study which has had the specific objectives of the present investigation. However, the following three inquiries are pertinent especially to the initial phase of the present experiment. Others more germane to the factor analytic phase will be reviewed later in an appropriate place.

In the first of the three studies, Holmes developed part of the methodology and investigated for college students in general some of the basic questions and hypotheses which the present investigation will study in *specific known-groups at the high school level.* In the second, Singer tested, at the *fourth-grade level,* the validity of the generalized major hypothesis of the Substrata-Factor Theory of Reading. And in the third, Michael investigated differential success in a training program in two pilot populations of the U.S. Army Air Force. Although his statistical techniques were different, his results would have been predicted by the Substrata-Factor Theory. These studies will now be developed in greater detail.

1. Holmes (1948, 1954) investigated "Factors Underlying Major Reading Disabilities at the College Level" by modifying and extending the Wherry-Doolittle multiple correlation technique to yield substrata factors. A substrata analysis, as the Wherry-Doolittle-Holmes multiple correlation technique is called, (*a*) yields successive sets of subvariables; (*b*) gives each set a definite place in a complex hierarchy of subabilities; and (*c*) discovers statistically significant contributions which each subability in the hierarchy makes to the subcriterion immediately above it and also the major criterion itself.

By using the substrata technique, the proper experimental design, a working sample of 126, and a cross-validating sample of 94 college students, he was able to select, out of a total of 40 variables, only those which made a direct or an indirect statistically significant and independent contribution to the variances of the criteria, speed and power of reading. The selected variables numbered 7 for speed and 10 for power. This meant a tremendous increase in efficiency in teaching reading at the college level. For instead of the 40 variables (all of which are reported in the literature to be highly related to reading), the teacher now need be concerned with only 13 (a 4-variable overlap for speed and power was discovered), plus other variables not tested for in this study.

Even more important, from a theoretical point of view, was the fact that the mathematically related hierarchy of subabilities which the substrata analysis produced gave a clearer picture of how such subskills might be organized by the mind for the purpose of solving a reading problem. Here, then, was a statistical model of a functioning brain, a model which caught something of the dynamics involved by showing how subskills might be integrated to form more complicated and higher level abilities.

Specifically, out of the 40 variables referred to above, the "Flow-Sheet" (fig. 1) depicts those that the substrata analysis selected out of the matrix as making direct or indirect independent contributions to speed and/or power of reading. By way of example, the chart may be read as follows: the use of phonetics (see third order, left-hand side of chart) is important to speed of reading because, along with vocabulary-in-context, span of recognition, and some other abilities not tested for in this analysis,[1] it enters into the constellation of subabilities that make up "word sense." Word sense, then, combines with intelligence, spelling, and vocabulary-in-context, and together these make contributions as factors underlying the skill which we call "word discrimination." Finally, on the highest level, word sense, word discrimination, and span of recognition become integrated to culminate in what we measure as Speed of Reading per se. Similarly, the hierarchy leading to Power of Reading may be worked out starting with, say, phonetics. The number adjacent to the name of each variable gives its percent contribution to the variance of the predicted criterion or subcriterion.

2. Singer (1960) attempted a theoretical integration of conceptual ability into the Substrata-Factor Theory of Reading and tested several hypotheses derived from this integration by analyzing the results of 36 tests given to 60 elementary school pupils. Substrata and centroid factor analyses of his data confirmed, at the *fourth-grade level*, the fundamental hypothesis of the Substrata-Factor Theory, originally formulated and substantiated at the *college level* by Holmes (1954):

> General reading is a composite of "speed" and "power" of reading, and underlying each component is a multiplicity of related and measurable factors. Disabilities in reading should, therefore, bear an inverse relationship to the quantitative levels of each such component and, hence, manifest detectable deficiencies in such underlying factors.

The following hypothesis was also confirmed: A substrata analysis of a matrix of appropriate subskills will precipitate various conceptual

---

[1] From the flow sheet (fig. 1), it is obvious that a residual or unaccounted-for variance in the criterion must be attributed to variables not assessed in this study.

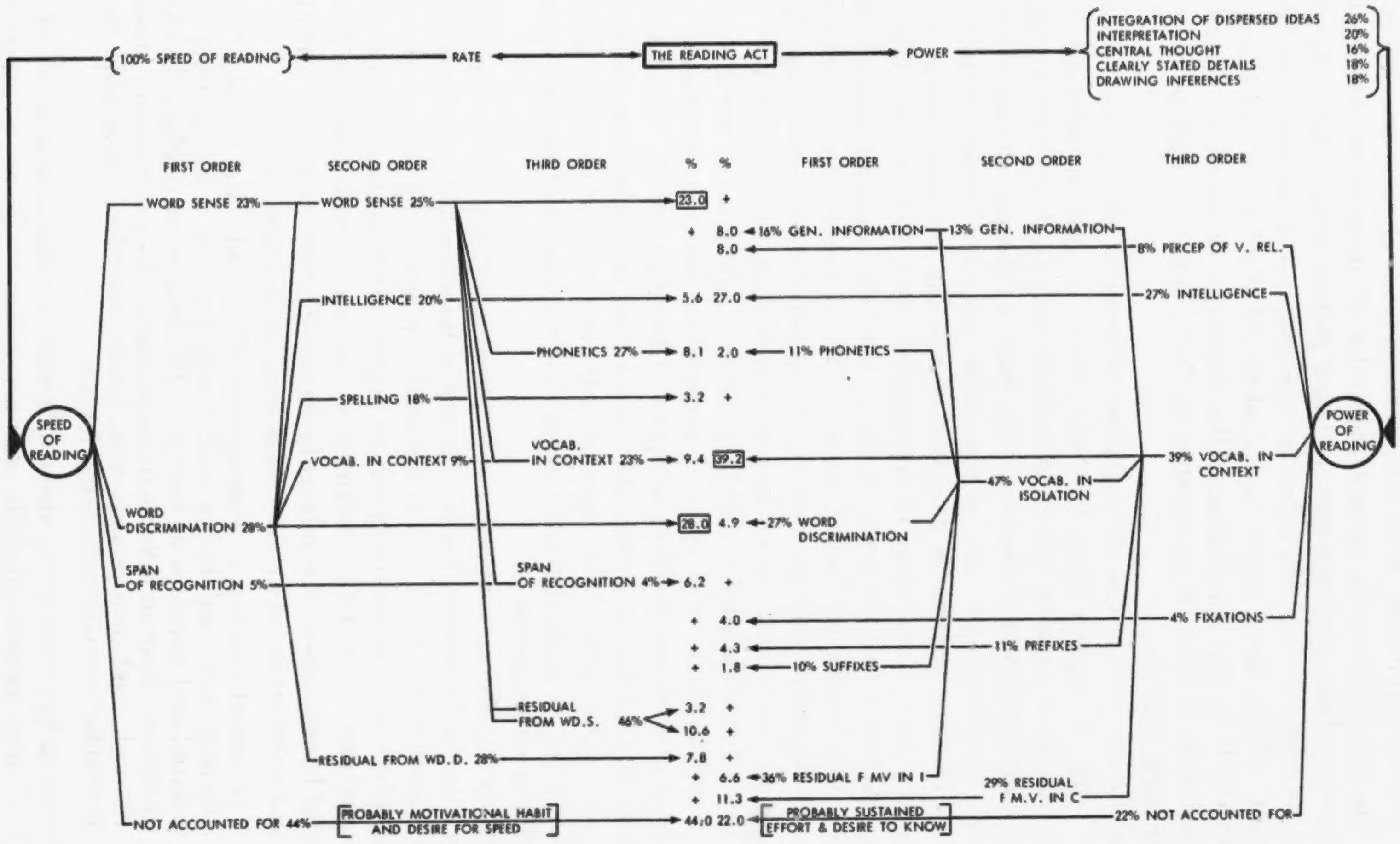

100% SPEED OF READING
RATE
THE READING ACT
POWER
INTEGRATION OF DISPERSED IDEAS 26%
INTERPRETATION 20%
CENTRAL THOUGHT 16%
CLEARLY STATED DETAILS 18%
DRAWING INFERENCES 18%
FIRST ORDER
SECOND ORDER
THIRD ORDER
%
%
FIRST ORDER
SECOND ORDER
THIRD ORDER
SPEED OF READING
POWER OF READING
WORD SENSE 23%
WORD SENSE 25%
23.0 +
+ 8.0
16% GEN. INFORMATION
13% GEN. INFORMATION
8.0
8% PERCEP OF V. REL.
INTELLIGENCE 20%
5.6 27.0
27% INTELLIGENCE
PHONETICS 27%
8.1 2.0
11% PHONETICS
SPELLING 18%
3.2 +
VOCAB. IN CONTEXT 9%
VOCAB. IN CONTEXT 23%
9.4 39.2
39% VOCAB. IN CONTEXT
47% VOCAB. IN- ISOLATION
WORD DISCRIMINATION 28%
28.0 4.9
27% WORD DISCRIMINATION
SPAN OF RECOGNITION 5%
SPAN OF RECOGNITION 4%
6.2 +
+ 4.0
4% FIXATIONS
+ 4.3
11% PREFIXES
+ 1.8
10% SUFFIXES
RESIDUAL FROM WD.S. 46%
3.2 +
10.6 +
RESIDUAL FROM WD. D. 28%
7.8 +
+ 6.6
36% RESIDUAL F MV IN I
29% RESIDUAL F M.V. IN C
+ 11.3
NOT ACCOUNTED FOR 44%
PROBABLY MOTIVATIONAL HABIT AND DESIRE FOR SPEED
44.0 22.0
PROBABLY SUSTAINED EFFORT & DESIRE TO KNOW
22% NOT ACCOUNTED FOR

Figure 1.—Flowchart for the tasks involved in the reading act, with breakdown for underlying factors.

abilities as important subabilities underlying individual differences in speed and/or power of reading.

A centroid factor analysis demonstrated that Speed and Power of Reading are multidimensional abilities which subsume different amounts of the same centroid factors. Both the centroid *and* substrata factor analyses yielded evidence to indicate that a shift in the reading task necessitates a reorganization in the working-system of the fourth-grade reader.

The substrata analysis, depicted in figure 2, revealed that there are at least three substrata factor sequences at the fourth-grade level. These may be broadly categorized as word-meaning, word-recognition, and reasoning-in-context. More specifically, figure 2 shows that Power of Reading at the first level of analysis is dependent upon Mental Age, Suffixes, Vocabulary in Isolation, and Matching Sounds in Words; a suppressor-like effect augmented the contributions to variance of the selected variables. Next to the names of the predictor variables are their percent contributions to variance of the criterion being predicted. From this set of predictors it can be inferred that in Power of Reading the reader brings to bear upon the reading task those mental processes which enable him to relate ideas, infer relations, abstract and generalize; in short, to reason while he is reading. In so doing, he calls upon his ability to remember the meanings of words and his capacity for analyzing and discriminating their meaning from contextual clues. If the reader does not know a word at sight, but can associate its meaning when he hears the word, then he can increase his power of reading through his skill in sounding out a word presented in its whole word form. Thus, visual and aural factors complement each other in the transformation of printed stimuli into mental processes so that meaning can be associated to them from the reader's experiential background and conceptual processes. Altogether 89 percent of the variance of Power of Reading was accounted for by these four variables selected out of the total matrix.

Vocabulary in Isolation was further analyzed into Mental Age, Suffixes, Word Recognition in Context, and a residual intrinsic to Vocabulary ability. From these predictors, it can be inferred that Vocabulary is dependent on the capability of developing a meaningful residual from events and situations, the ability to discriminate and judge meanings of words, and skills in using context clues and other word-recognition processes for transforming visual stimuli into mental processes for the association of meaning.

Matching Sounds in Words was also analyzed at the second level. Underlying it were Spelling Recall and Blending Word Sounds, and something intrinsic to Matching Sounds in Words. At the third level, the variance in Word Recognition in Context was accounted

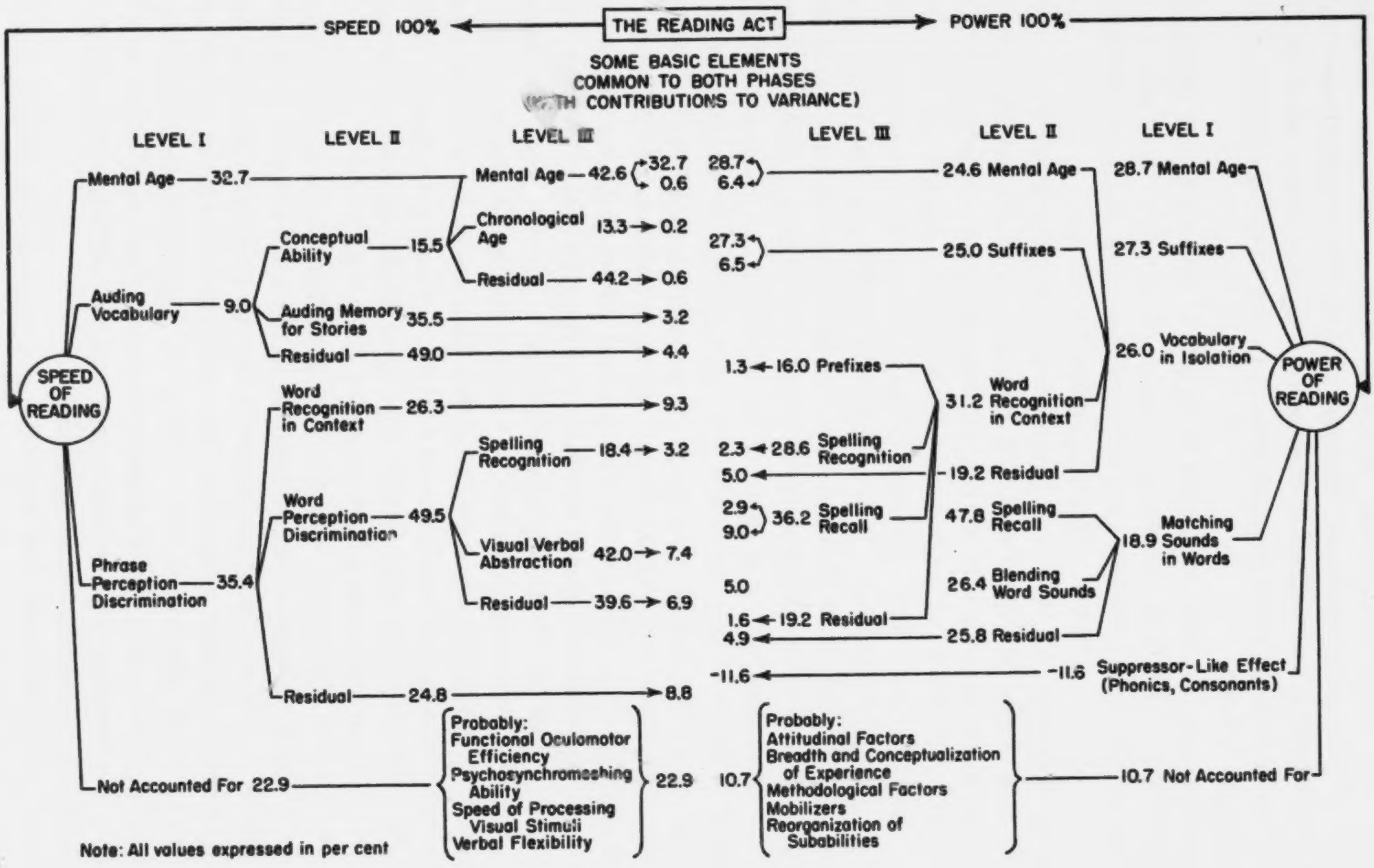

SPEED 100%
THE READING ACT
POWER 100%
SOME BASIC ELEMENTS
COMMON TO BOTH PHASES
(WITH CONTRIBUTIONS TO VARIANCE)
LEVEL I
LEVEL II
LEVEL III
LEVEL III
LEVEL II
LEVEL I
Mental Age — 32.7
Mental Age — 42.6
32.7
0.6
Chronological Age 13.3 → 0.2
Residual — 44.2 → 0.6
Conceptual Ability — 15.5
Auding Vocabulary — 9.0
Auding Memory for Stories 35.5 → 3.2
Residual — 49.0 → 4.4
SPEED OF READING
Word Recognition in Context — 26.3 → 9.3
Spelling Recognition — 18.4 → 3.2
Word Perception Discrimination — 49.5
Visual Verbal Abstraction 42.0 → 7.4
Residual — 39.6 → 6.9
Phrase Perception Discrimination — 35.4
Residual — 24.8 → 8.8
Not Accounted For 22.9
Probably:
Functional Oculomotor Efficiency
Psychosynchromeshing Ability
Speed of Processing Visual Stimuli
Verbal Flexibility
22.9
Note: All values expressed in per cent
28.7
6.4
24.6 Mental Age
28.7 Mental Age
27.3
6.5
25.0 Suffixes
27.3 Suffixes
26.0 Vocabulary in Isolation
POWER OF READING
1.3 ← 16.0 Prefixes
31.2 Word Recognition in Context
2.3 ← 28.6 Spelling Recognition
5.0 ← 19.2 Residual
2.9
9.0
36.2 Spelling Recall
47.8 Spelling Recall
18.9 Matching Sounds in Words
5.0
26.4 Blending Word Sounds
1.6 ← 19.2 Residual
4.9 ← 25.8 Residual
-11.6 ← -11.6 Suppressor-Like Effect (Phonics, Consonants)
10.7
Probably:
Attitudinal Factors
Breadth and Conceptualization of Experience
Methodological Factors
Mobilizers
Reorganization of Subabilities
10.7 Not Accounted For

Figure 2.—Flowchart to show the results of the substrata analysis of Speed and Power of Reading at the fourth-grade level.

for by Spelling Recognition, Prefixes, Spelling Recall, and something intrinsic to Word Recognition in Context. These substrata sequences demonstrate, in agreement with Holmes' findings (1954, 1959), the communality and differences in both types of spelling (recall and recognition) and word-recognition abilities; they also emphasize the prominence of the word-recognition substrata in reading at the intermediate grade level.

3. Michael (1949) compared two AAF pilot populations, using both factor analytic and multiple correlation techniques. His study investigated the factorial structure and the value of a battery of tests for predicting success in two different pilot training populations of the U.S. Army Air Force. The two known-groups consisted of 815 West Point cadets and 356 Negro cadets. Eighteen tests were given the West Point cadets and 21 were administered to the Negro cadets. The scores were placed in stanine form, and the resultant intercorrelations were factor analyzed.

The factors which emerged were: verbal, number, reasoning, perceptual speed, spatial relations, mechanical experience, pilot-interest, psychomotor coordination, and a kinesthetic factor.

From the point of view of the present study, however, the most interesting finding of Michael's work was the fact that while "pilot-interest" was the most important factor contributing to success for the West Point cadets, the "kinesthetic" factor was the most important for the Negro cadets. Each group, of course, was in competition with itself only. Fron the standpoint of the Substrata-Factor Theory, the implication is clear: differently constituted subgroups of flying cadets call upon (a) different subabilities, and (b) different amounts of the same subabilities, in order to succeed in intragroup competition at the same task, viz., to succeed in the AAF pilot training program.

SECTION II

SAMPLE, TESTS, AND METHODOLOGY

Chapter III. The Subjects

A total sample of 400 students[1] was drawn at random from the total population of students attending the University of California Demonstration Secondary School during the summer of 1953. Table 1 presents a breakdown of the sample by grade and sex. The right-hand column gives the percent sampled from the actual number enrolled in each grade.

Informal interviews, conducted by counselors to uncover reasons behind formal declarations, revealed that students took work in summer session in order to make up a failure, improve a grade, add a "solid," follow an interest in a special subject outside their declared course of study (e.g., typing for college-preparatory students), or to work off an extra solid or two in order to have more time to participate in sports or engage in student government activities in the coming year. Furthermore, some students indicated that parents wanted them to attend, that a friend of the family had suggested it; that a friend was going; or that they wanted to graduate from high school in 3 years, and this was a way to do it.

Table 1.—Sample classified according to grade and sex

Grade	Male sample	Female sample	Total sample	School total	Sample total / School Total
	N	N	N	N	Percent
IX	35	26	61	131	46. 6
X	62	54	116	208	55. 8
XI	80	79	159	251	63. 3
XII	34	30	64	118	54. 2
Total	211	189	400	[1]708	56. 5

[1] The total student body contained 951 students, but the 243 (951–708) students not indicated in the table were special students; not in grades IX, X, XI, or XII, they were, for the most part, 8th-graders enrolled in summer school for a single music or band class.

---

[1] Actually 428 were drawn, but 28 were deleted in order to "purify" the homogeneity of the working sample. Of the 28, 20 were in grade VIII, 2 in college, and 6 were over 21 years of age. In general, the eighth-graders were taking band or orchestra, and those over 21 years were foreign students.

The students in the sample came from 67 different schools and gave as their "home address" 28 different towns or cities in California. Four students came from out of State, and one from the island of Tahiti.

Unlike any other high school, the Demonstration School draws pupils from the entire San Francisco Bay area; consequently, the students in the Demonstration School are more likely to be representative of the general high school population than a sample drawn from any one school during the regular academic year.

Chapter IV. The Tests and Their Reliability

Tests Used in Assessing *Dependent* Variables

S. Speed of Reading, Criterion Test. The criterion, Speed of Reading, was assessed on the Diagnostic Examination of Silent Reading Abilities: Rate of Comprehension Scale; Part I, Form B by Van Wagenen (1953). This test is constructed on the validity-assumption that the faster a subject can detect the use of an absurd word within a relatively simple paragraph, the faster is his rate of reading comprehension.

Sample: Jane needed a spool of silk thread to finish her new dress. But when she went to the store for her mother she forgot to get the ~~buttons~~ she needed.

P. Power of Reading, Criterion Test. The criterion scores on Power of Reading were computed by summing the equivalent C-scores obtained in the following five subtests of the Dvorak-Van Wagenen Diagnostic Examination of Silent Reading Abilities: Junior Division; Part III, Form M (1952):

a. Ability to grasp the central thought of the paragraph.
b. Ability to note the clearly stated details.
c. Ability to interpret the content of the paragraph.
d. Ability to grasp an idea when spread through several sentences.
e. Ability to draw inferences from ideas in a paragraph.

Each subtest contains 20 tasks, arranged in a heterogeneous manner to avoid "mental set." The validity of this test is prima facie, insofar as the student must read and understand the material and meaning of the paragraph to be able to answer the various questions asked about each. Note that this is a power test, since there is no time limit; and each student could reread any or all of the subtest paragraphs as many times as he felt necessary for him to grasp the meaning. The task is much like that which a student faces when he does his homework. He reads a chapter and then answers the questions at the end. If he cannot answer them, he goes back and rereads the passage with a new mental set, adjusted to the specific questions being asked.

Sample Paragraph

It was Perez, a friar, on whom Columbus called with his little son Diego, and explained his need for men and ships to prove the world is round. The friar interested his friend, Queen Isabella of Spain, in the plans of Columbus. But when the three ships that carried Columbus to America sailed from Spain, Diego was left to stay at the palace of the Queen until his father should come back.

Sample Questions

A. The paragraph is mainly about
1. Perez, the friar. 2. Queen Isabella. 3. the ships in which Columbus sailed. 4. the voyage of Columbus. 5. the palace of the Queen . . . .

B. Perez had been a friend of
1. Columbus. 2. Diego. 3. Queen Isabella. 4. Diego's father. 5. the father of Columbus . . . .

C. Diego was left at home because he was
1. a friar. 2. too young. 3. not interested. 4. afraid to go. 5. didn't know his father was going. . . . . .

D. When Diego was left at the palace, he was
1. happy. 2. glad. 3. relieved. 4. joyous. 5. unhappy . . . .

In spite of the opportunity to reread each passage, marked individual differences in performance on this reading test were very evident at the high school level.

Tests Used in Assessing *Independent* Variables

A. Mental Abilities

The SRA Primary Mental Abilities Test; Intermediate, Form AM by Thurstone and Thurstone (1948) was used to assess various dimensions of mental ability. The subtests purport to tap the following mental abilities:

1. *Visual Verbal Meaning Test.* This test is designed to assess the ability to understand ideas when they are expressed in words.

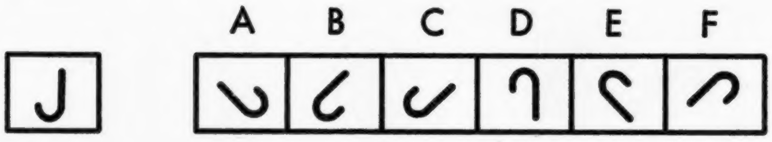
Sample: The first word in the following line is BIG

BIG	A. Ill	B. Large	C. Down	D. Sour

One of the words means the *same* as BIG. This word is *Large*. *Large* is answer B.

2. *Spatial Relations Test.* This test assesses the ability to imagine how an object or figure will look when rotated or rearranged in space.

Sample: A B C D E F



Figures C, E, and F are LIKE the first figure.

3. *Inductive Reasoning Test.* This test is meant to assess the ability to solve logical problems, i.e., to foresee and plan. However, it does so in a very narrow range of context.

Sample: Study the series of letters below. What letter should come NEXT?

c a d a e a f a

g	a	c

You should have blackened *g* on the Answer Sheet.

4. *Word Fluency Test.* The Word Fluency Test was designed to assess the ability to write and talk easily. This ability differs from Visual Verbal Meaning because it concerns the speed and ease with which words can be used, rather than the degree of understanding of verbal concepts.

Sample: Look at the words in the list below. Each word begins with *d*

doll
dinner
daisy

When the examiner gives the signal, you will be given a *new* letter. You are to write as many words as you can which begin with the new letter.

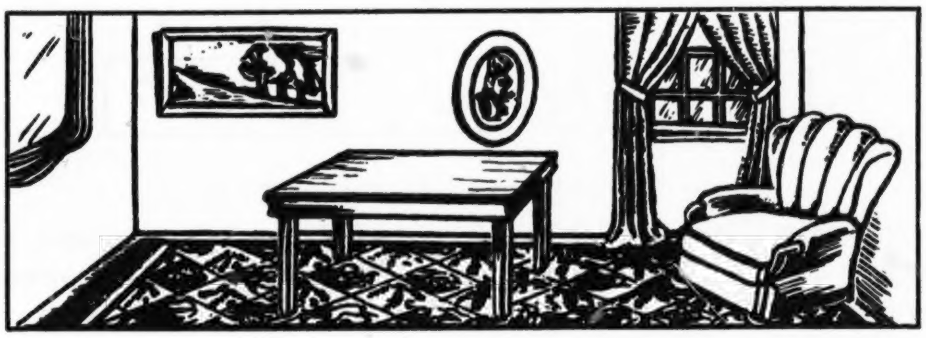
5. *Speed of Addition Test.* The Speed of Addition Test is supposed to assess basic *number* ability; i.e., the ability to handle simple quantitative problems rapidly and accurately.

Sample: Check the sums of the problems below.

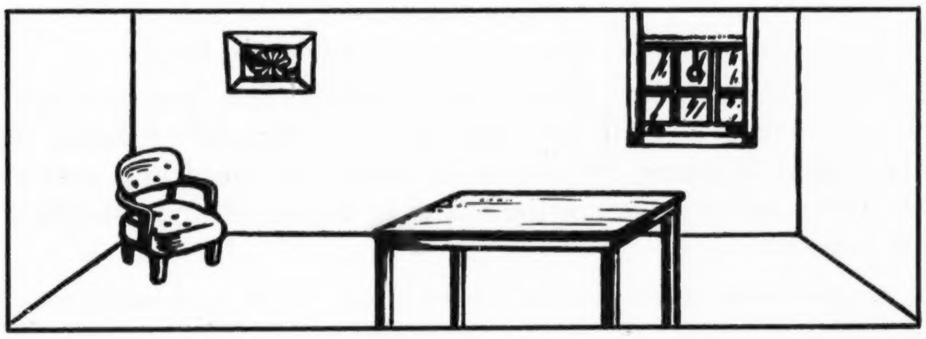
16	42
38	61
45	83
89	186

6. *Mechanical Aptitude Test.* Mechanical ability was tested on the Bennett and Fry Test of Mechanical Comprehension, Form BB (1941). This test purports to measure the capacity of an individual to understand various types of physical and mechanical relationships. This kind of ability is important in mechanical jobs, in many trades, in engineering, and in the physical sciences. Some students may have it and call upon it to help them solve problems in power reading; others may not have it and, therefore, could not call upon it as one of their "strengths."

Sample: Which room has more of an echo?



A



B

7. *Verbal Analogies Test.* The subtest, Verbal Analogies (Perception of Relations), taken from the Dvorak-Van Wagenen Diagnostic Examination of Silent Reading Abilities: Junior Division; Part II, Form M (1952) was used to assess individual differences in this area of verbal intelligence.

Sample: sky : blue :: grass : 1. grows 2. hay 3. ripe 4. green 5. lawn

B. Linguistic Abilities

The linguistic abilities which prior research had indicated might be related to reading ability at this level were assessed on certain subscales of two standardized tests and one semistandardized test.

From Part II, Form M, of the Dvorak-Van Wagenen Diagnostic Examination of Silent Reading Abilities: Junior Division, the following subscales were used:

8. *Vocabulary in Context Test.* The stimulus words were taken from the first 10,000 words in the Thorndike Word List, and were included in short sentences to give the exact meaning. The five words, from which one is to be selected, are all more difficult than the stimulus word. This approximates the situation when one is trying to think

of the best word to express some meaning that one has in mind.

Sample: He felt very *sad* 1. timid 2. happy 3. weary 4. sorrowful 5. hungry

9. *Vocabulary in Isolation Test.* The content of the Vocabulary in Isolation scale was also taken from the first 10,000 words in the Thorndike Word List. By contrast, in each task, the five words from which one is to be selected are all easier than the stimulus word. The difficulty values of words were derived from testing some 800 pupils in grades IV, VI, VIII, and XII.

Sample: simple-------- 1. hard 2. funny 3. easy 4. busy 5. tiny

10. *Range of Information Test.* The items of this scale were selected from many different fields of information that are not emphasized in classroom work, yet lie within the experience of school pupils.

Sample: The sun rises in the 1. evening 2. west 3. south 4. morning 5. north

From the Diagnostic Examination of Visual Perception and Linguistic Abilities by Holmes (1954), the following subscales were used:

11. *Phonetic Association Test.* This is a test of ability to recognize a word correctly when given only its phonetic spelling. The task is to see a word that is spelled more or less the way it sounds, recognize the sound, and write it correctly. If the student's written response could be recognized as the correct word, even if misspelled, it was given credit in this test.

Sample: In the examples below, read the word and sound it to yourself. Then write the correct spelling for that word in the space to the right of it.

1. mlk milk
2. hpy happy
3. rng ring
4. jmp ________
5. laf ________
6. enuf ________

12. *Word Sense Test.* This test is for the purpose of assessing the student's ability to think of the correct word in a paragraph when given only a hint. Vocabulary, syntax, context cues, and phonetic associations are all called upon to decide which words would be best to use in the blanks in order to give the paragraph its best overall meaning. NOTE: The Word Sense Test is the forerunner of "Cloze" Test.

Sample: As you read the paragraph, decide in each case what word the underlined letter-group or ________ _____ seems to represent. Your word sense will tell you what word the author would use Write the correct words in the answer column.

A high skl^{a} student wks^{b} at many	a. school
activities. He stdys^{c} his hmwk,^{d}	b. works
attends clses,^{e} and may have a	c. studies
part-time ____^{f}.	d. homework
	e. classes
	f. job

13. *Homonymic Meaning Test.* This test is designed to assess the student's ability to discriminate between two words which look and sound very similar, and to identify the one which has the same meaning as the keyword. The Homonymic Meaning Test is very similar to the Word-Discrimination Test used by Holmes (1948, 1954) in his college study and the Word Recognition in Context Test used by Singer (1960) at the fourth-grade level.

Sample: DIRECTIONS: Each *keyword* on the left is followed by several choices. If one of the choices has the *same meaning as the Keyword,* place a heavy black *mark between the pair of dotted lines on the answer sheet which has the same number* as your choice.

If no correct answer is given, mark the fifth choice (col. 5) on the answer sheet for that item.

EXAMPLES

Keyword(s)	*Choices*			
A. surpass	(1) exceed	(2) accede		(5)
B. low tone	(1) base	(2) bass	(3) boss	(5)

14, 15. *Prefixes and Suffixes Tests.* In the test on common prefixes and suffixes, the student is asked to select from four definitions the one which means the same as the affix.

Sample: DIRECTIONS: The *un-* part of the word "unusual" is called a prefix. *Un* means "not" in this case; thus, the word *unusual* means "not usual." The *-ous* part of the word "famous" is called a suffix. *Ous* means "full of" in this case; thus, the word *famous* means "full of fame."

EXAMPLES

Prefix	*Choices*			
un-	(1) with	(2) along	(3) not	(4) over
Suffix				
-ous	(1) full of	(2) more	(3) less	(4) greatest

16. *Latin and Greek Roots Test.* In this test, a list of English words constituting a "word family" is used; then the root from which they have been derived is given. After each root, a series of definition-words is given, only one of which has the same meaning as the root.

Here the student examines the word family and from several words abstracts the meaning of the common root.

Sample: A. Exceed, succeed, concede, intercede, and recede are all derived from the Latin root *cedere* which means: (1) to prosper, (2) to agree, (3) to fight, (4) to be with, (5) to go.

NOTE: YOU ARE NOT EXPECTED TO KNOW THE ROOT, BUT YOU ARE EXPECTED TO TRY TO *REASON IT OUT.*

For instance, your reasoning in the above example should go something like this:

exceed	means to	surpass,	or to go beyond
succeed	" "	achieve,	or to go on
concede	" "	yield,	or to go along with
intercede	" "	intervene,	or to go between
recede	" "	withdraw,	or to go back

Therefore, *to go* is the common-root-idea which forms the basis of all these words. Hence, you should mark (5) on the answer sheet.

17. *Visual Spelling Recognition Test.* In this Multiple Choice Spelling Test each word is spelled in four different ways. The student is to choose the one which he thinks is spelled correctly.

Sample:

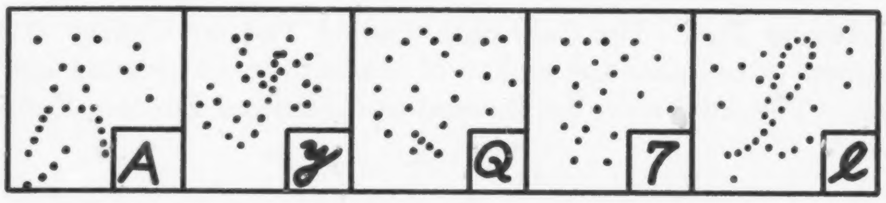
	Choices				*Correct spelling not given*
	1	2	3	4	5
A.	donn	dahn	done	duune	(5)

C. Visual-Verbal Perception

Visual-Verbal Perception was measured on four subtests in Section A of the Diagnostic Examination of Visual Perception and Linguistic Abilities by Holmes (1954). The subscales used are as follows:

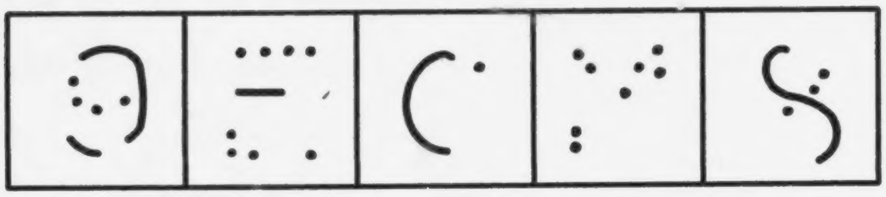
18. *Dot Figure and Ground Test.* This dot-embedded configuration test assesses the student's ability to detect the dotted outline of a letter or number when it is hidden in a cloud of dots. The "hidden" dot-symbol must be abstracted as a figure from the random dots that make up the background.

Sample: DIRECTIONS: 1. This is a test of your ability to *see the dotted outline of a letter or number when it is hidden in a cloud of dots.* 2. If you see more than one figure, choose the one that appears to you to be the best or "strongest."



19. *Cue-Symbol Closure Test.* This dot-and-line configuration test is designed to determine the ability of the student to induce from a minimum of visual cues what block letter or number might be constructed from such cues.

Sample: The dots and lines may make more than one figure; if so, any one will do. Some have more than one right answer.



20. *Word Embedded Test.* The Word Embedded Test is another exercise in figure and ground, using both meaningful and nonsense verbal symbol combinations. A simple word is embedded, or hidden, in four different nonsense letter combinations, and the student is asked to abstract from the four the *largest* meaningful and common element making up a word.

Sample:

				Hidden word
aboato	boato	erboat	anboat	boat

21. *Perception of Reversals Test.* This serial-order letter-reversal test requires the student to detect serial-order similarities and differences in pairs of nonsense words or letter combinations. Taking the test as a whole, ascenders, scenders, and descenders are arranged to come systematically at initial, central, and final positions in the two letter combinations offered. Mirror-image letters and letter combinations are used as distractors to true serial-order reversals.

Sample: If the serial order of the pair of letter-groups is exactly reversed from the first part to the second, mark "T" for "True" on your answer sheet.

A. bux	xub	A. True	F
B. bux	xud	B. T	False
C. qcghuh	huhgaq	C. T	F
D. abcde	ebcda	D. T	F

REMEMBER: IF THE *SAME* LETTERS ARE EXACTLY REVERSED, MARK "*T*"; OTHERWISE MARK "*F*."

D. Listening Comprehension

22. *Auding Test.* The California Auding Test by Caffrey (1952) is designed to estimate the ability of students to understand spoken English. The total score on Revised Standardized Edition, Form F, was used.

Directions: This test calls for no reading and no writing on your part. I'll read to you and ask you questions about what I read.

Sample: "Columbus was a general (PAUSE) a chemist (PAUSE) an explorer (PAUSE—AND THEN, WITH FINAL INTONATION) a Turkish prince."

On your answer sheet you would blacken space (3) to indicate that the third answer, "an explorer," is the best one.

Section four contains vocabulary items.

For example, the word is *shade:*

Sample: She used a *shade* too much lipstick.

In this sentence, *shade* means

absence of light color a little a screen

E. Auditory Perception and Elements of Musical Ability

Holmes' modification (1954) of the Kwalwasser-Dykema Test for Aptitude in Elements of Music (1930) was used to measure the various elements of auditory images. The rationale for including this test in the battery rests on the hypothesis that within the substrata factors which underlie certain audiovisual verbal abilities like spelling, phonetics, auding, etc., one might expect to find individual differences in the elements of auditory images. The following subscales constituted the battery of tests.

23. Tonal Memory
24. Tone-Quality Discrimination
25. Tone-Intensity Discrimination
26. Tonal Movement
27. Tone-Time Interval Discrimination
28. Rhythm Discrimination
29. Pitch Discrimination
30. Musical Taste

F. Academic Attitudes-Habits

The California Study Methods Tests, Form 4–B, by Carter (1954) was used to judge four aspects of studiousness:

31. *School Adjustment and Morale Test.* This scale measures self-confidence and happiness in school situations.

32. *Scholarly Values Test.* This is a scholarly motivation and values test and assesses the degree to which a student has the same values and attitudes of his peers who are the successful scholars.

33. *Mechanics of Study Test.* This scale seeks to evaluate the techniques the student uses when he is studying.

34. *Effective Study Plan Test.* This planning-and-deliberation scale measures the student's tendency to make a systematic approach to the problem of getting schoolwork done.

G. Interest

The Kuder Preference Record for Vocational Interest, Form CM (1948), was used to estimate individual differences in the interests of students. The statement has often been heard that a student simply is not interested in reading, and that is why he is a poor reader. Or, a student is interested in other things, and that is why he will not read books. The question arises, then, does manifest interest in a nonliterary direction preclude excellence in reading, on the one hand, and/or does manifest interest in literature assure success in reading, on the other? To answer these kinds of questions, the 10 following interest scales of the Kuder Preference Record were used:

35. Outdoor Interest
36. Mechanical Interest
37. Computational Interest
38. Science Interest
39. Persuasive Interest
40. Artistic Interest
41. Literary Interest
42. Musical Interest
43. Social Service Interest
44. Clerical Interest

H. Emotional-Social Problems

The SRA Youth Inventory, Form A, by Remmers and Shimberg (1949) was used to estimate the degree to which different types of teenage problems were being experienced by the students in our sample. Since it is believed that success and failure in schoolwork can both affect, and be affected by, the emotional and social problems (real or fancied) experienced by a student, this battery was included in the pool of tests in the hope that some of the analysis might tease out pertinent relationships between reading and various kinds of problems, should they exist. The specific areas assessed by the SRA Youth Inventory are:

45. School Problems
46. Postgraduation Anxieties
47. Problems with Self
48. Problems with Others
49. Home-Family Problems
50. Boy-Girl Problems
51. Health Problems
52. Things in General

I. Musicality

53. *Musical Appreciation Test.* The Kyme (1954) Test of Musicality was used to appraise the students' esthetic judgment of music. It was expected that capability as shown by a good score in this test might be related to success in auding.

J. Age

54. *Chronological Age.* The chronological age of each student in the sample was given in months.

Psychometric Characteristics of Instruments Used

Table 2 presents in summary form the test names, number of items per test, time limits for each test, and reliability data for the *dependent* and *independent* variables. All reliabilities were taken from the publishers' manuals, except for the 12 subtests of the Holmes (1954) Diagnostic Examination of Visual Perception and Linguistic Abilities.[1] These reliabilities were calculated from the scores of the first 100 subjects drawn in the present sample of 400 by the odd-even or separately timed halves method, whichever was appropriate. All such Pearson product moment reliabilities were corrected by the Spearman-Brown Prophecy Formula. It will be readily observed upon scrutinizing the table that all but two of the various subtest reliabilities surpass by a comfortable margin Kelley's (1947) minimal standard for group testing.

Table 2.—Psychometric characteristics of instruments used in assessing dependent and independent variables

Variable	Number of items	Test time (in minutes)	Test reliability
Dependent			
S. Speed of Reading	56	5	0.98
P. Power of Reading	100	[1] U	.94
Independent			
A. Mental abilities:			
1. Visual verbal meaning	50	4	.92
2. Spatial relations	20	5	.96
3. Inductive reasoning	30	6	.93
4. Word fluency	[2] X	5	.90
5. Speed of addition	70	6	.89
6. Mechanical aptitude	60	U	.80
7. Verbal analogies	40	U	.92
B. Linguistic abilities:			
8. Vocabulary in context	40	U	.93
9. Vocabulary in isolation	40	U	.91
10. Range of information	40	U	.89
11. Phonetic association	100	16	.97
12. Word sense	75	18	.97
13. Homonymic meaning	60	8	.94
14. Prefixes	20	5	.77
15. Suffixes	20	5	.68
16. Latin and Greek roots	35	7	.87
17. Visual spelling recognition	35	5	.94
C. Verbal perception:			
18. Dot figure and ground	216	8	.93
19. Cue-symbol closure	108	7	.91
20. Word embedded	100	9	.98
21. Perception of reversals	120	10	.98

See footnotes at end of table.

---

[1] The revised editions, Forms A and B, of Holmes' battery may be obtained from the Psychological-Educational Services Association, Pebble Beach, California.

Table 2.—Psychometric characteristics of instruments used in assessing dependent and independent variables—Continued

Variable	Number of items	Test time (in minutes)	Test reliability	
Independent—Continued				
D. Listening comprehension:				
22. Auding	75	[3] CT	0.88	
E. Elements of musical ability:				
23. Tonal memory	25	CT	.73	
24. Tone-quality	30	CT	.70	
25. Tone-intensity	30	CT	.79	
26. Tonal movement	30	CT	.88	
27. Tone-time interval	25	CT	.50	
28. Rhythm	25	CT	.71	
29. Pitch	40	CT	.72	
30. Musical taste	20	CT	.43	
			Boys	*Girls*
F. Academic attitudes—habits:				
31. School adjustment and morale	15	U	0.68	0.74
32. Scholarly values	15	U	.71	.64
33. Mechanics of study	18	U	.44	.47
34. Effective study plan	17	U	.89	.93
G. Interest:				
35. Outdoor interest	123	U	.90	.89
36. Mechanical interest	102	U	.93	.86
37. Computational interest	84	U	.86	.85
38. Science interest	105	U	.89	.90
39. Persuasive interest	128	U	.86	.84
40. Artistic interest	78	U	.90	.90
41. Literary interest	63	U	.88	.87
42. Musical interest	45	U	.90	.84
43. Social service interest	120	U	.85	.86
44. Clerical interest	153	U	.86	.90
			Total	
H. Emotional-social problems:				
45. School problems	33	U	0.84	
46. Postgraduation anxieties	37	U	.90	
47. Problems with self	44	U	.88	
48. Problems with others	40	U	.88	
49. Home-family problems	53	U	.94	
50. Boy-girl problems	32	U	.87	
51. Health problems	25	U	.75	
52. Conflict in values	34	U	.89	
I. Musicality:				
53. Musical appreciation	52	CT	.80	

[1] U=Unlimited time.

[2] X=Any number of responses the subject gives within time limit.

[3] CT=Controlled time; i.e., item is read or played to students who have a given amount of time to respond.

Chapter V. Statistical Methodology of the Substrata-Factor Analysis

The Wherry-Doolittle-Holmes Substrata-Factor Analysis (Holmes, 1948, 1954) is an extension of the Wherry-Doolittle Test Selection Method (Garrett, 1947). This extension makes it possible to discover not only the "best" [1] team of tests out of a total battery that might be selected for the prediction of a criterion, but also allows one to determine the substructural organization of the various elements which underlie a particular criterion or subcriterion. In other words, while the Wherry-Doolittle gives the best team of tests for predicting the success of a criterion at the *first* level, the extension of the method, i.e., the substrata analysis, yields those substrata factors at the *second* and *third* levels which best account for the distribution of variance in *each* of the tests selected as predictors in the *first* and *second* level. The process may be thought of as a derivative analysis which yields sets of predictor tests at levels which are successively more and more remotely related to the major criterion.

The substrata-factor analysis begins by selecting first that test in the total correlation matrix which is the most valid predictor of the criterion. After partialing out from the correlation matrix that part of the variance in the criterion which has been accounted for by the first selected variable, a systematic search is made among the rest of the variables for the next best predictor; that is, the one which will account for the greatest amount of residual variance in the criterion. The method then systematically proceeds to partial out from the matrix the variance accounted for by the first and the second selected variables and then to search systematically among the remaining variables in the matrix for that particular one which will make the next greatest contribution to the variance of the criterion over and above that already accounted for by the first and second selected tests. The process of selecting more and more predictors continues until an F-test, applied to the results, indicates that, at the 1-percent level of confidence, the last selected variable no longer makes a significant contribution to the variance of the criterion over and above that already accounted for by the previously selected tests.

It is a well-recognized fact that the process of selecting a set of variables from an array of tests by this technique inadvertently capitalizes on the variation of chance factors in sampling, and that this leads to an overestimation of the multiple correlation for the general population. Wherry, in modifying the Doolittle method for computing the multiple correlation, developed a shrinkage formula to correct systematically for this cumulative bias inherent in the original test selection method. The application of the shrinkage formula enables one to adjust the Doolittle multiple correlation so that it will be a better estimate of the multiple correlation that would be obtained if the same selected variables were used to predict the same criterion in another sample selected from the same population. *The formula used for shrinking the biased estimate of* R *is as follows:*

---

[1] "Best" in the sense that a minimum number of preferential variables are selected which tend to yield the maximum prediction of the criterion.

$$\overline{R}^2=1-\left[(1-R^2)\left(\frac{N-1}{N-m-1}\right)\right]$$

where:

$\overline{R}$ equals the "shrunken R" or adjusted multiple correlation,
R equals the biased estimate of the multiple correlation,
N equals the sample size,
m equals the number of predictors selected.

In the present study, the selection of additional predictors for each substrata criterion was stopped when the F-test indicated that the null hypothesis *could not* be rejected at the 1-percent level of confidence.[2]

The McNemar (1955) F-test is expressed by the following formula:

$$F=\frac{R_1^2-R_2^2/(m_1-m_2)}{(1-R_1^2)/(N-m_1-1)}$$

where:

R_1 is the multiple correlation based on the selected m_1 variables,[3]
R_2 is the multiple correlation based on m_2 variables, selected from among the m_1 variables,
N is the sample size,
m_1 is the number of predictors previously selected,
F is the resulting ratio which is determined to be, or not to be, significant by entering a table in which $n_1=m_1-m_2$, and $n_2=N-m_1-1$. Where: n_1 and n_2 are degrees of freedom.

---

[2] The Wherry *stopping rule* (Wherry, 1947) proved to be unsatisfactory under the conditions of the present study. The reason lies in the fact that the tests themselves were selected with great care so that there was a very gradual gradient from the highest to the lowest correlations of the independent variables with each criterion. This, in combination with the use of the IBM 701 and 704 digital computers, where the calculations are carried out to eight or more decimal places, caused the Wherry stopping rule to be virtually inoperable. That is, it is a very rough-and-ready rule that is best applied when one is carrying calculations out to only four decimal places and where the variables in the battery show broad jumps in the size of the zero-order correlations with the criterion. In other words, the Wherry stopping rule tends to stop the extraction of tests when there is a wide gap between the sizes of the zero-order correlation of the "last selected test with the criterion" and the one about to be selected and is, therefore, rejected as not making a significant independent contribution to the variance of the criterion over and above that accounted for by the previously selected tests. Under the present conditions of IBM accuracy and the nature of the test battery, a continuously shrinking *increase* was detectable in the sixth, seventh, and eighth decimal place. Such increases were completely beyond the sensitivity of the Wherry stopping rule. However, the McNemar (1955) F-test proved to work very well even under the conditions specified above.

[3] In the present study, m_1 was taken as the R computed from the selection of just one more variable and inversion of the matrix. Therefore, in each F-test, $m_1-m_2=1$. This modification was used as the most conservative estimate for a random selection.

By means of the F-test, as used here, one is able to determine whether or not a next best test, added to the team of tests already selected, makes a statistically significant contribution to the criterion under consideration. That is, the null hypothesis is tested at the 1-percent level of confidence ($R_1 - R_2 = 0$).

In order to proceed with the explanation, it is necessary to introduce the notion of *subcriteria.* Let us say that the best prediction of the main criterion, *Speed of Reading,* is given by a set of five variables; then these five predictor variables at *Level I* are designated as subcriteria, and each one is now analyzed to discover those independent variables which underlie it at *Level II.* Then proceeding to the next level, one asks, "What are the variables at *Level III* which best account for the variance of the preferential variables found at *Level II*?" The diagram in figure 3 depicts a substrata analysis in schematic form with generalized notation which shows how a "predictor" variable becomes a "subcriterion" for the next level of analysis.

To attain a simplified substrata structure of the hierarchy of abilities which underlie reading, the general rule is applied that, once a variable has been used, it cannot be used again at a subsequent level. This is a refinement of the method followed by Holmes (1948) and by Singer (1960). This refinement, or modification, toward a simplified structure results directly from the nature of the original pool of tests. After careful consideration of the literature, the tests, in fact, were selected or constructed to assess all those facets of the mind which might "explain" speed or power of reading. Because of this concerted effort, the battery included a great number of tests each of which correlates highly with the criteria, Speed and Power of Reading. Furthermore, as has been indicated before, throughout the entire range there is a gradual decrease in zero-order correlation with the two main criteria, Speed and Power, and with each of the subcriteria as well. These conditions cause the substrata analysis to turn in on itself much faster than it was observed to do in either the Holmes (1948, 1954) or the Singer (1960) studies, and hence, necessitated the development of the refined or "simplified structure technique."

Three related points, however, should be mentioned: (1) Not all selected predictor variables are used as subcriteria in a subsequent substrata analysis. If a variable appears to be so fundamental that it would be difficult to justify an explanation of it in terms of any of the other variables used in the study, it is not further analyzed; and (2) the overall substrata analysis is halted when, in the judgment of the experimenter, the hierarchy of explainable variables has reached a point of diminishing returns. The substrata-factor hierarchy that is built up by the substrata analysis *tends* to select out of the total matrix at the first level those variables which, by virtue of their high com-

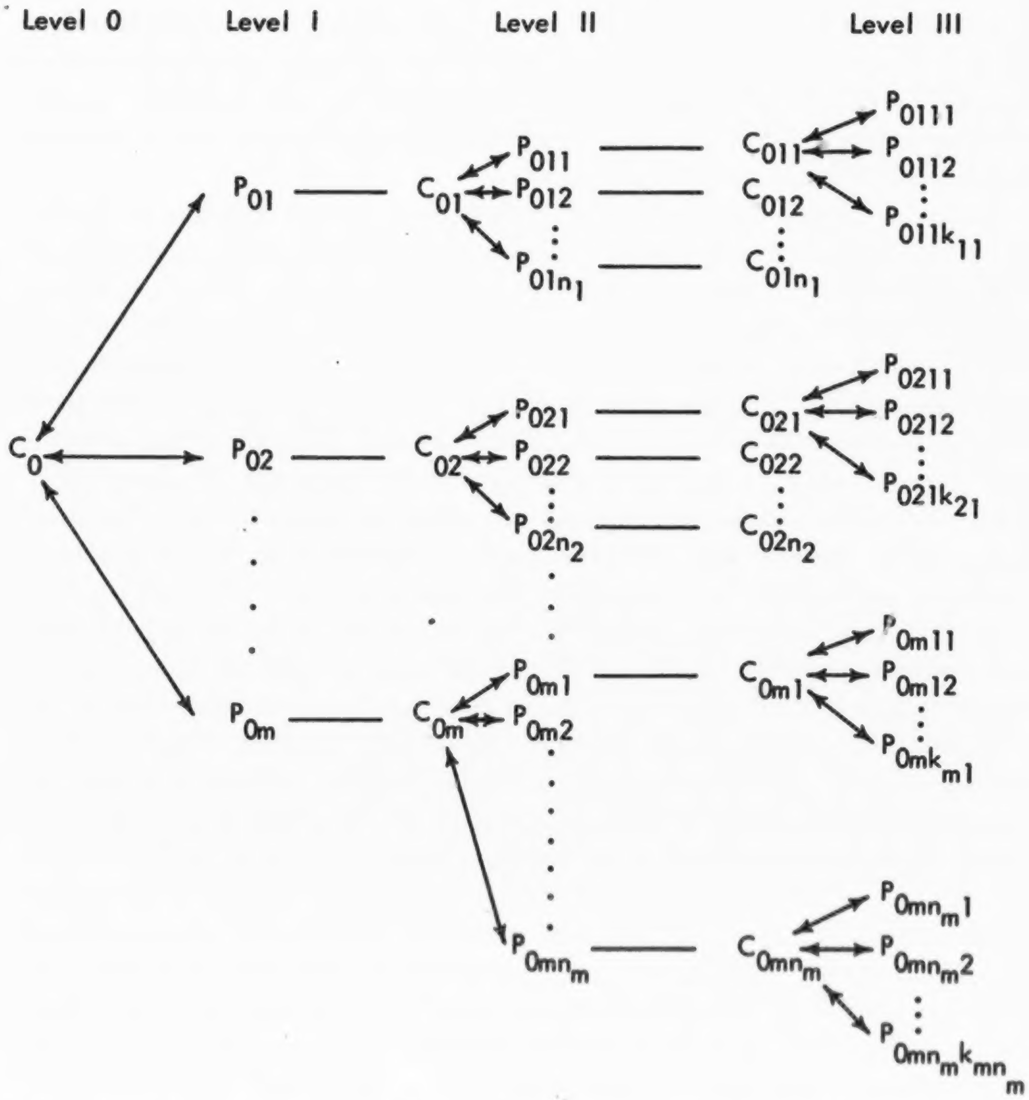

Level 0
Level I
Level II
Level III
C0
P01
P02
P0m
C01
C02
C0m
P011
P012
P01n1
P021
P022
P02n2
P0m1
P0m2
P0mnm
C011
C012
C01n1
C021
C022
C02n2
C0m1
C0mnm
P0111
P0112
P011k11
P0211
P0212
P021k21
P0m11
P0m12
P0mkm1
P0mnm1
P0mnm2
P0mnmkmnm

Figure 3.—Schematic diagram with generalized notation of a substrata analysis through three levels.

Note: Major criterion C_0 is undergirded by substrata factors P_{01}, P_{02}, . . . P_{0m}. Each of these rests on a wider base at Level II. Likewise, at Level III the base is even broader. P_{0m}–C_{0m} terminology is used to indicate an identity, except that what was considered a predictor is in turn considered a subcriterion.

plexity, are relatively more closely related to success in the Speed or Power of Reading criterion than are the other variables in the matrix. The point of diminishing returns is reached when a subcriterion, precipitated from the matrix at any particular level, is already so fundamental that there are no other variables left in the matrix which psychoeducational judgment would consider as likely candidates to explain its variance at the next level. (3) Because the regression lines of X on Y and Y on X are not the same, the statistical model used in the substrata analysis does not reflect the reciprocal contributions to variance outlined in the Theory; that is, the reciprocal percent contributions to variance cannot be inferred from the one-directional substrata analysis of the preferential predictors of the criteria and subcriteria at subsequent levels in the hierarchy of the working system. However, the new W–D–H program for the 7094 has been designed to calculate not only the X on Y *and* Y on X substrata analyses, but also the fractionated contributions resulting from the joint or shared variance. Kling (1964) in a doctoral study utilized this program for the purpose of determining the mutual and reciprocal contributions of the school subjects at the junior high school level.

Finally, the substrata analysis also calculates the contribution to variance which each of the selected variables makes to the criterion and calculates, at the next level, what the subpredictors contribute to the variance of each of the subcriteria by multiplying each of the zero-order r's by its appropriate beta weight. The generalized formula is as follows:

$$R^2=\beta_{01}r_{01}+\beta_{02}r_{02}+\beta_{03}r_{03}+\ .\ .\ .\ +\beta_{0n}r_{0n}$$

where:

R^2 is the "accounted for" or predicted variance,
β is the beta weight; that is, the partial regression coefficient. For the first variable, β_{01} in its generalized form is $\beta_{01.023\ldots n}$,
r is the zero-order correlation with the criterion.

The beta weights are found in the Wherry-Doolittle format by solving a set of simultaneous linear equations. This is equivalent to inverting the selected matrix of variables and substituting the elements of the matrix in the following general formula:

$$\beta_{ij}=\frac{-r^{ij}}{r^{jj}}$$

where:

β_{ij} is the beta weight for the i^{th} variable for the j^{th} criterion,
r^{ij} is the inverse element of the i^{th} variable for the j^{th} criterion,
r^{jj} is the inverse element of the j^{th} variable for the j^{th} criterion.

When substituted in the above formula, these beta weights, together with the appropriate zero-order correlations, sum up to the raw, or unadjusted, R^2. However, what is really wanted is the percent contribution to variance of the criterion that each selected predictor makes *after* it has been corrected for bias of selection. To accomplish this correction, each percent contribution is multiplied by its ratio of $\overline{R}^2/R^2$. Thus, by prorating the values calculated from the foregoing formula, we have, in fact, calculated the contributions to variance after each preferential predictor has been adjusted for that bias which is inherent in the original test selection method. The formal expression may be indicated thus:

$$\bar{R}^2 = \bar{\beta}_{01}\bar{r}_{01} + \bar{\beta}_{02}\bar{r}_{02} + \bar{\beta}_{03}\bar{r}_{03} + \ldots + \bar{\beta}_{0n}\bar{r}_{0n},$$

$$\bar{R}^2 = \bar{B}_{01}r_{01} + \bar{B}_{02}r_{02} + \bar{B}_{03}r_{03} + \ldots + \bar{B}_{0n}r_{0n}$$

and each of these terms is converted into percent contribution to the variance of the criterion simply by multiplying through by 100. (NOTE: The $\bar{R}^2$ is obtained from the shrinkage formula given on p. 32; while, the R^2 of the ratio $\bar{R}^2/R^2$ is obtained from the formula on p. 35.)

SECTION III

THE SUBSTRATA-FACTOR ANALYSES

Chapter VI. A Substrata-Factor Analytic Study of Speed and Power of Reading for the Total Sample of High School Students

Introduction

The major hypothesis of this entire investigation is concerned with discovering differences in the substrata-factor patterns which underlie Speed and/or Power of Reading in various known-groups: boys vs. girls, bright vs. dull readers, fast vs. slow readers, and powerful vs. non-powerful readers. One may inquire then, why the study makes a detailed analysis of the total group from which the known-subgroups are drawn. The answer and rationale for this approach is twofold: First, *in psychology as in medicine, the abnormal can only be truly understood in terms of the normal*; hence, the true interpretations of the substrata factors of the extreme groups can be understood only in terms of the generalized patterns manifested by the total group. The second point is that the total group constitutes a "known-group" in itself and therefore must be studied in its own right in order to get the overall picture for the high school population.

The complex nature of the investigation of the total group necessitates a separate substrata analysis for each of the criteria, Speed and Power of Reading. The findings, therefore, will be presented in two parts.

Part I. Substrata Analysis for Speed of Reading: Total Sample

Table 3 gives the means and standard deviations, and table 4 presents the matrix of intercorrelations for the variables in the total sample of 400 high school students.

As shown in table 4, the correlation of 0.594 between Speed and Power of Reading makes it evident that an appreciable relationship exists between these two criteria. Since one of the purposes of the present chapter is to discover the substructural nature of this very relationship, the influence of each criterion on the other must be removed from the common matrix before the separate analyses are begun. To accomplish this fractionation, when Speed of Reading is being analyzed, the zero-order correlations of each of the variables with Power of Reading are deleted from the matrix. In part II of this chapter, the reverse is true; that is, when Power of Reading is being analyzed, the zero-order r's for Speed of Reading are deleted.

Table 3.—Mean and standard deviation on each variable for total sample, N=400

Variable	Mean	Standard deviation
Dependent		
S. Speed of Reading	21. 04	7. 81
P. Power of Reading	68. 58	16. 51
Independent		
A. Mental abilities:		
1. Visual verbal meaning	30. 34	10. 36
2. Spatial relations	21. 99	11. 78
3. Inductive reasoning	15. 79	6. 62
4. Word fluency	35. 28	11. 88
5. Speed of addition	18. 18	8. 21
6. Mechanical aptitude	32. 06	6. 92
7. Verbal analogies	27. 04	7. 59
B. Linguistic abilities:		
8. Vocabulary in context	31. 75	7. 12
9. Vocabulary in isolation	31. 16	6. 52
10. Range of information	29. 74	6. 30
11. Phonetic association	52. 44	24. 39
12. Word sense	35. 34	18. 83
13. Homonymic meaning	31. 55	10. 51
14. Prefixes	8. 56	3. 56
15. Suffixes	7. 09	3. 39
16. Latin and Greek roots	14. 16	5. 80
17. Visual spelling recognition	23. 62	6. 29
C. Verbal perception:		
18. Dot figure and ground	137. 09	27. 45
19. Cue-symbol closure	62. 33	13. 61
20. Word embedded	66. 34	20. 24
21. Perception of reversals	78. 45	20. 33
D. Listening comprehension:		
22. Auding	31. 91	7. 84
E. Elements of musical ability:		
23. Tonal memory	21. 12	5. 68
24. Tone-quality	27. 58	5. 18
25. Tone-intensity	31. 97	7. 77
26. Tonal movement	35. 81	11. 22
27. Tone-time interval	22. 95	5. 07
28. Rhythm	23. 48	4. 53
29. Pitch	35. 19	7. 37
30. Musical taste	25. 96	6. 61
F. Academic attitudes-habits:		
31. School adjustment and morale	50. 73	9. 78
32. Scholarly values	49. 92	9. 86
33. Mechanics of study	50. 08	9. 86
34. Effective study plan	50. 64	10. 80

Table 3.—Mean and standard deviation on each variable for total sample, N=400—Continued

Variable	Mean	Standard deviation
Independent—Continued		
G. Interest:		
35. Outdoor	39. 42	15. 09
36. Mechanical	31. 70	13. 68
37. Computational	24. 09	9. 00
38. Science	39. 20	14. 71
39. Persuasive	39. 38	11. 26
40. Artistic	29. 13	10. 50
41. Literary	19. 74	8. 19
42. Musical	16. 24	7. 65
43. Social service	42. 85	14. 26
44. Clerical	50. 07	14. 02
H. Emotional-social problems:		
45. School problems	6. 15	4. 15
46. Postgraduation anxieties	11. 34	8. 05
47. Problems with self	6. 88	6. 52
48. Problems with others	7. 23	6. 43
49. Home-family problems	4. 89	6. 38
50. Boy-girl problems	4. 28	4. 94
51. Health problems	3. 04	3. 02
52. Conflict in values	4. 97	6. 15
I. Musicality:		
53. Musical appreciation	29. 96	6. 10
J. Age:		
54. Chronological age	197. 06	14. 40

Table 4.—Correlation matrix for the total high school sample, N=400

Variable	S.	P.	1	2	3	4	5	6
S. Speed of Reading	---	594	656	242	512	306	225	170
P. Power of Reading	594	---	671	294	512	319	252	278
1. Visual verbal meaning	656	671	---	304	528	359	303	287
2. Spatial relations	242	294	304	---	451	140	256	404
3. Inductive reasoning	512	512	528	451	---	295	451	259
4. Work fluency	306	319	359	140	295	---	249	054
5. Speed of addition	225	252	303	256	451	249	---	132
6. Mechanical aptitude	170	278	287	404	259	054	132	---
7. Verbal analogies	468	727	551	380	511	252	244	399
8. Vocabulary in context	579	785	676	317	467	264	211	326
9. Vocabulary in isolation	571	779	673	295	435	284	190	326
10. Range of information	552	742	633	303	428	266	192	389
11. Phonetic association	477	493	606	230	426	376	292	163
12. Word sense	582	579	686	217	462	368	291	175
13. Homonymic meaning	575	535	649	284	502	284	304	198
14. Prefixes	440	463	471	169	377	243	233	226
15. Suffixes	378	341	387	184	325	252	206	206
16. Latin and Greek roots	483	480	559	253	408	210	324	256
17. Visual spelling recognition	478	429	533	180	387	271	326	046
18. Dot figure and ground	369	348	437	290	426	290	235	277
19. Cue-symbol closure	267	354	392	437	397	234	307	379
20. Word embedded	415	365	427	317	453	376	320	106
21. Perception of reversals	293	231	310	341	416	150	401	095
22. Auding	597	745	626	305	471	252	146	357
23. Tonal memory	294	352	370	291	453	231	300	237
24. Tone-quality	211	279	278	194	316	177	188	200
25. Tone-intensity	253	364	324	198	373	216	170	237

26. Tonal movement	268	326	352	240	417	160	211	184
27. Tone-time interval	113	166	167	150	239	099	129	134
28. Rhythm	236	229	253	125	277	232	191	154
29. Pitch	285	292	339	229	340	205	219	211
30. Musical taste	176	238	238	107	268	259	217	141
31. School adjustment and morale	219	233	246	083	205	115	112	026
32. Scholarly values	066	084	086	029	131	034	113	−050
33. Mechanics of study	010	083	099	019	081	014	033	028
34. Effective study plan	104	123	143	047	132	072	197	022
35. Outdoor interest	−043	008	039	149	−002	−047	−001	313
36. Mechanical interest	−157	−090	−108	225	−062	−093	049	467
37. Computational interest	−229	−181	−160	054	−069	−074	140	161
38. Science interest	−006	059	041	154	−010	006	066	333
39. Persuasive interest	012	−000	−018	−090	−038	−033	007	−150
40. Artistic interest	−005	056	−008	055	030	061	−036	−108
41. Literary interest	264	189	244	−045	039	064	006	−065
42. Musical interest	037	023	055	−060	051	049	033	−133
43. Social service interest	019	−041	−082	−157	−001	−058	−085	−276
44. Clerical interest	−169	−210	−175	−110	−000	−047	024	−291
45. School problems	−200	−221	−220	−073	−118	−110	−156	−066
46. Postgraduation anxieties	−188	−128	−179	−077	−135	−053	−105	003
47. Problems with self	−100	−049	−096	−049	−091	−045	−114	−109
48. Problems with others	−113	−046	−118	−046	−031	−079	−115	−022
49. Home-family problems	−018	005	024	025	−003	−018	−025	−028
50. Boy-girl problems	−072	−037	−118	−089	−109	−049	−139	−064
51. Health problems	−029	−013	−026	−025	−020	015	−075	−022
52. Conflict-values	−009	035	−017	−100	−093	−022	−088	−083
53. Music appreciation	161	246	246	146	272	136	203	105
54. Chronological age	−081	−017	−008	−035	−078	063	120	−010

Table 4.—Correlation matrix for the total high school sample, N=400—Continued

Variable	7	8	9	10	11	12	13	14
S. Speed of Reading	468	579	571	552	477	582	575	440
P. Power of Reading	727	785	779	742	493	579	535	463
1. Visual verbal meaning	551	676	673	633	606	686	649	471
2. Spatial relations	380	317	295	303	230	217	284	169
3. Inductive reasoning	511	467	435	428	426	462	502	377
4. Word fluency	252	264	284	266	376	368	284	243
5. Speed of addition	244	211	190	192	292	291	304	233
6. Mechanical aptitude	399	326	326	389	163	175	198	226
7. Verbal analogies	---	722	694	709	437	491	435	431
8. Vocabulary in context	722	---	852	749	537	607	551	448
9. Vocabulary in isolation	694	852	---	794	548	606	541	424
10. Range of information	709	749	794	---	469	547	496	411
11. Phonetic association	437	537	548	469	---	872	712	535
12. Word sense	491	607	606	547	872	---	793	602
13. Homonymic meaning	435	551	541	496	712	793	---	604
14. Prefixes	431	448	424	411	535	602	604	---
15. Suffixes	335	312	324	345	450	503	480	534
16. Latin and Greek roots	412	457	472	450	516	591	598	621
17. Visual spelling recognition	346	477	454	404	632	640	642	513
18. Dot figure and ground	334	363	361	341	323	346	362	320
19. Cue-symbol closure	399	345	341	339	308	337	349	374
20. Word embedded	284	312	309	226	410	438	466	395
21. Perception of reversals	175	256	196	163	362	387	433	376
22. Auding	671	718	711	705	442	552	498	490
23. Tonal memory	353	303	298	280	284	262	243	203
24. Tone-quality	221	199	218	231	204	205	156	144
25. Tone-intensity	295	278	338	292	209	249	238	189

26. Tonal movement	288	259	263	279	241	262	230	179
27. Tone-time interval	139	136	145	133	065	080	080	109
28. Rhythm	235	235	255	220	250	222	143	146
29. Pitch	294	279	314	298	280	257	234	196
30. Musical taste	274	222	186	159	267	258	206	218
31. School adjustment and morale	253	193	223	210	220	203	196	193
32. Scholarly values	071	067	033	074	129	098	117	153
33. Mechanics of study	097	089	086	069	042	071	088	078
34. Effective study plan	015	042	036	034	110	148	115	138
35. Outdoor interest	096	028	001	039	−111	−072	−063	022
36. Mechanical interest	064	−037	−009	003	−181	−138	−143	−100
37. Computational interest	−104	−213	−188	−087	−198	−203	−098	−023
38. Science interest	071	039	079	147	−054	−027	004	093
39. Persuasive interest	−006	−009	001	−028	006	−022	−032	−073
40. Artistic interest	066	038	016	021	095	037	015	017
41. Literary interest	145	203	217	160	216	219	241	165
42. Musical interest	−034	030	−004	−000	106	069	004	−032
43. Social service interest	−129	−055	−075	−150	022	009	004	034
44. Clerical interest	−250	−224	−223	−187	−064	−153	−098	−128
45. School problems	−195	−218	−225	−183	−207	−220	−215	−220
46. Postgraduation anxieties	−131	−129	−135	−096	−147	−173	−138	−114
47. Problems with self	−106	−092	−079	−084	−118	−095	−102	−100
48. Problems with others	−074	−079	−094	−071	−134	−103	−127	−073
49. Home-family problems	−010	−012	011	030	013	000	−022	−037
50. Boy-girl problems	−126	−078	−074	−045	−034	−044	−112	−105
51. Health problems	−129	−045	−051	−062	−058	−054	−025	−048
52. Conflict-values	−089	−014	003	−008	−031	−006	−032	−024
53. Music appreciation	217	283	264	200	258	261	190	188
54. Chronological age	−081	−081	−046	−116	−022	057	013	104

Table 4.—Correlation matrix for the total high school sample, N=400—Continued

Variable	15	16	17	18	19	20	21	22
S. Speed of Reading	378	483	478	369	267	415	293	597
P. Power of Reading	341	480	429	348	354	365	231	745
1. Visual verbal meaning	387	559	533	467	392	427	310	626
2. Spatial relations	184	253	180	290	437	317	341	305
3. Inductive reasoning	325	408	387	426	397	453	416	471
4. Word fluency	252	210	271	290	234	376	150	252
5. Speed of addition	206	324	326	235	307	320	401	146
6. Mechanical aptitude	206	256	046	277	379	106	095	357
7. Verbal analogies	335	412	346	334	399	284	175	671
8. Vocabulary in context	312	457	477	363	345	312	256	718
9. Vocabulary in isolation	324	472	454	361	341	309	196	711
10. Range of information	345	450	404	341	339	226	163	705
11. Phonetic association	450	516	632	323	308	410	362	442
12. Word sense	503	591	640	346	337	438	387	552
13. Homonymic meaning	480	598	642	362	349	466	433	498
14. Prefixes	534	621	513	320	374	395	376	490
15. Suffixes	---	473	382	253	258	268	282	348
16. Latin and Greek roots	473	----	494	323	315	375	302	489
17. Visual spelling recognition	382	494	---	314	330	507	492	326
18. Dot figure and ground	253	323	314	---	542	428	302	310
19. Cue-symbol closure	258	315	330	542	---	450	367	339
20. Word embedded	268	375	507	428	450	---	452	265
21. Perception of reversals	282	302	492	302	367	452	---	191
22. Auding	348	489	326	310	339	265	191	---
23. Tonal memory	140	258	214	258	233	268	225	312
24. Tone-quality	131	161	123	148	199	214	198	249
25. Tone-intensity	199	222	162	197	188	233	199	280

26. Tonal movement	189	263	136	198	183	236	175	313
27. Tone-time interval	020	095	005	066	106	107	076	169
28. Rhythm	146	162	133	140	113	160	103	197
29. Pitch	173	183	207	230	275	273	254	218
30. Musical taste	170	173	168	118	147	213	160	221
31. School adjustment and morale	196	169	166	096	107	154	119	242
32. Scholarly values	064	085	114	049	089	145	133	039
33. Mechanics of study	067	052	135	055	112	141	122	078
34. Effective study plan	086	121	153	034	010	134	061	080
35. Outdoor interest	−051	−025	−135	091	136	009	−022	085
36. Mechanical interest	−050	−046	−138	036	188	−058	−047	−031
37. Computational interest	−013	−008	−084	−095	013	−116	096	−129
38. Science interest	049	085	−024	033	109	011	069	121
39. Persuasive interest	−037	−016	012	−033	−041	−065	−039	−029
40. Artistic interest	−046	−098	046	136	167	075	051	−028
41. Literary interest	134	190	158	015	−022	054	−002	202
42. Musical interest	011	007	079	−050	−137	−029	004	000
43. Social service interest	−023	−051	013	−090	−110	070	032	−090
44. Clerical interest	−107	−135	−012	−159	−161	−078	030	−218
45. School problems	−120	−172	−177	−131	−134	−136	−172	−226
46. Postgraduation anxieties	−061	−120	−147	−133	−064	−151	−206	−167
47. Problems with self	−035	−109	−136	−108	−107	−064	−194	−112
48. Problems with others	−019	−085	−155	−096	−065	−091	−149	−091
49. Home-family problems	009	−031	−039	064	009	029	−075	−006
50. Boy-girl problems	−068	−105	−116	−156	−128	−148	−151	−102
51. Health problems	050	−024	−036	−066	−097	−018	−065	−075
52. Conflict-values	−028	−028	−056	−063	−103	−049	−102	−048
53. Music appreciation	037	141	146	131	157	152	180	279
54. Chronological age	097	091	022	−049	041	114	150	−071

Table 4.—Correlation matrix for the total high school sample, N=400—Continued

Variable	23	24	25	26	27	28	29	30
S. Speed of Reading	294	211	253	268	113	236	285	176
P. Power of Reading	352	279	364	326	166	229	292	238
1. Visual verbal meaning	370	278	324	352	167	253	339	238
2. Spatial relations	291	194	198	240	150	125	229	107
3. Inductive reasoning	453	316	373	417	239	277	340	268
4. Word fluency	231	177	216	160	099	232	205	259
5. Speed of addition	300	188	170	211	129	191	219	217
6. Mechanical aptitude	237	200	237	184	134	154	211	141
7. Verbal analogies	353	221	295	288	139	235	294	274
8. Vocabulary in context	303	199	278	259	136	235	279	222
9. Vocabulary in isolation	298	218	338	263	145	255	314	186
10. Range of information	280	231	292	279	133	220	298	159
11. Phonetic association	284	204	209	241	065	250	280	267
12. Word sense	262	205	249	262	080	222	257	258
13. Homonymic meaning	245	156	238	230	080	143	234	206
14. Prefixes	203	144	189	179	109	146	196	218
15. Suffixes	140	131	199	189	020	146	173	170
16. Latin and Greek roots	258	161	222	263	095	162	183	173
17. Visual spelling recognition	214	123	162	136	005	133	207	168
18. Dot figure and ground	258	148	197	198	066	140	230	118
19. Cue-symbol closure	233	199	186	183	106	113	275	147
20. Word embedded	268	214	233	236	107	160	273	213
21. Perception of reversals	225	198	199	175	076	103	254	160
22. Auding	312	249	280	313	169	197	218	221
23. Tonal memory	---	392	390	455	362	331	438	344
24. Tone-quality	392	---	537	413	377	380	426	335
25. Tone-intensity	390	537	---	422	372	332	413	357

26. Tonal movement	455	413	422	---	234	289	375	295
27. Tone-time interval	362	377	372	234	---	303	329	225
28. Rhythm	331	380	332	289	303	---	400	321
29. Pitch	438	426	413	375	329	400	---	417
30. Musical taste	344	335	357	295	225	321	417	---
31. School adjustment and morale	113	049	103	176	064	119	108	014
32. Scholarly values	150	040	016	023	088	147	105	−031
33. Mechanics of study	052	007	049	048	026	−084	028	023
34. Effective study plan	110	030	035	050	078	019	058	096
35. Outdoor interest	044	051	017	011	059	036	024	040
36. Mechanical interest	−009	079	076	020	078	−051	031	−013
37. Computational interest	−010	060	012	−086	049	−110	009	−111
38. Science interest	051	050	097	−002	089	002	058	038
39. Persuasive interest	−039	−033	−027	011	−078	−021	−051	021
40. Artistic interest	068	−039	−023	008	000	047	003	031
41. Literary interest	030	002	−012	−024	−020	030	063	012
42. Musical interest	231	127	015	157	074	187	146	070
43. Social service interest	−061	−054	−000	−000	−028	−001	−005	−037
44. Clerical interest	−131	−046	−119	−082	−021	−130	−101	−158
45. School problems	−101	−043	−025	−014	−038	−031	−091	−129
46. Postgraduation anxieties	−104	−093	016	−096	018	028	000	−021
47. Problems with self	−083	−033	045	−025	015	019	−062	−023
48. Problems with others	−046	−015	030	−016	−007	005	−035	−068
49. Home-family problems	−021	003	010	−006	029	−045	007	−002
50. Boy-girl problems	−095	006	000	−048	−030	065	−015	−065
51. Health problems	−015	016	059	−037	−010	038	−046	−035
52. Conflict-values	−024	007	064	−019	−019	062	019	−031
53. Music appreciation	372	309	275	334	273	324	377	513
54. Chronological age	−108	−053	−023	−084	032	006	−054	025

Table 4.—Correlation matrix for the total high school sample, N=400—Continued

Variable	31	32	33	34	35	36	37	38
S. Speed of Reading	219	066	010	104	−043	−157	−229	−006
P. Power of Reading	233	084	083	123	008	−090	−181	059
1. Visual verbal meaning	246	086	099	143	039	−108	−160	041
2. Spatial relations	083	029	019	047	149	225	054	154
3. Inductive reasoning	205	131	081	132	−002	−062	−069	−010
4. Word fluency	115	034	014	072	−047	−093	−074	006
5. Speed of addition	112	113	033	197	−001	049	140	066
6. Mechanical aptitude	026	−050	028	022	313	437	161	333
7. Verbal analogies	253	071	097	015	096	064	−104	071
8. Vocabulary in context	193	067	089	042	028	−037	−213	039
9. Vocabulary in isolation	223	033	086	036	001	−009	−188	079
10. Range of information	210	074	069	034	039	003	−087	147
11. Phonetic association	220	129	042	110	−111	−181	−198	−054
12. Word sense	203	098	071	148	−072	−138	−203	−027
13. Homonymic meaning	196	117	088	115	−063	−143	−098	004
14. Prefixes	193	153	078	133	022	−100	−023	093
15. Suffixes	196	064	067	086	−051	−050	−013	049
16. Latin and Greek roots	169	085	052	121	−025	−046	−008	085
17. Visual spelling recognition	166	114	135	153	−135	−138	−084	−024
18. Dot figure and ground	096	049	055	034	091	036	−095	033
19. Cue-symbol closure	107	089	112	010	136	188	013	109
20. Word embedded	154	145	141	134	009	−058	−116	011
21. Perception of reversals	119	133	122	061	−022	−047	096	069
22. Auding	242	039	078	080	085	−031	−129	121
23. Tonal memory	113	150	052	110	044	−009	−010	051
24. Tone-quality	049	040	007	030	051	079	060	050
25. Tone-intensity	103	016	049	035	017	076	012	097

26. Tonal movement	176	023	048	050	011	020	−086	−002
27. Tone-time interval	064	088	026	078	059	078	049	089
28. Rhythm	119	147	−084	019	036	−051	−110	002
29. Pitch	108	105	028	058	024	031	009	058
30. Musical taste	014	−031	023	096	040	−013	−111	038
31. School adjustment and morale	---	222	030	143	015	−053	−006	022
32. Scholarly values	222	---	064	070	−039	−094	049	018
33. Mechanics of study	030	064	---	179	032	−025	026	−025
34. Effective study plan	143	070	179	---	−012	014	116	123
35. Outdoor interest	015	−039	032	−012	---	443	100	441
36. Mechanical interest	−053	−094	−025	014	443	---	248	409
37. Computational interest	−006	049	026	116	100	248	---	385
38. Science interest	022	018	−025	123	441	409	385	---
39. Persuasive interest	−004	019	−079	−089	−413	−190	−233	−372
40. Artistic interest	010	−017	063	−057	−050	−137	−284	−366
41. Literary interest	117	022	058	−024	−223	−348	−032	−178
42. Musical interest	022	050	020	002	−226	−247	−155	−318
43. Social service interest	−035	034	−057	002	−126	−337	−290	−123
44. Clerical interest	021	085	−011	031	−395	−244	329	−270
45. School problems	−186	−051	−146	−157	057	112	030	−040
46. Postgraduation anxieties	−148	−027	−009	−018	−052	042	035	012
47. Problems with self	−185	−050	−115	−026	017	−024	−045	−061
48. Problems with others	−120	−030	−082	−060	031	029	−009	−055
49. Home-family problems	−028	−031	−087	−022	017	−021	−054	−025
50. Boy-girl problems	−097	−040	−028	−039	−032	−025	−026	−054
51. Health problems	−146	−085	−098	−075	−083	−067	−055	−053
52. Conflict-values	−071	−007	−003	000	−004	−073	−115	004
53. Music appreciation	048	024	078	−011	−049	−083	−159	−004
54. Chronological age	−113	−031	−019	003	015	057	020	016

Table 4.—Correlation matrix for the total high school sample, N=400—Continued

Variable	39	40	41	42	43	44	45	46
S. Speed of Reading	012	−005	264	037	019	−169	−200	−188
P. Power of Reading	−000	056	189	023	−041	−210	−221	−128
1. Visual verbal meaning	−018	−008	244	055	−082	−175	−220	−179
2. Spatial relations	−090	055	−045	−060	−157	−110	−073	−077
3. Inductive reasoning	−038	030	039	051	−001	−000	−118	−135
4. Word fluency	−033	061	064	049	−058	−047	−110	−053
5. Speed of addition	007	−036	006	033	−085	024	−156	−105
6. Mechanical aptitude	−150	−108	−065	−133	−276	−296	−061	003
7. Verbal analogies	−006	066	145	−034	−129	−250	−195	−131
8. Vocabulary in context	−009	038	203	030	−055	−224	−218	−129
9. Vocabulary in isolation	001	016	217	−004	−075	−223	−225	−135
10. Range of information	−028	021	160	−000	−150	−187	−183	−096
11. Phonetic association	006	095	216	106	022	−064	−207	−147
12. Word sense	−022	037	219	069	009	−153	−220	−173
13. Homonymic meaning	−032	015	241	004	004	−098	−215	−138
14. Prefixes	−073	017	165	−032	034	−128	−220	−114
15. Suffixes	−037	−046	134	011	−023	−107	−120	−061
16. Latin and Greek roots	−016	−098	190	007	−051	−135	−172	−120
17. Visual spelling recognition	012	046	158	079	013	−012	−177	−147
18. Dot figure and ground	−033	136	015	−050	−090	−159	−131	−133
19. Cue-symbol closure	−041	167	−022	−137	−110	−161	−134	−064
20. Word embedded	−065	075	054	−029	070	−078	−136	−151
21. Perception of reversals	−039	051	−002	004	032	030	−172	−206
22. Auding	−029	−028	202	000	−090	−218	−226	−167
23. Tonal memory	−039	068	030	231	−061	−131	−101	−104
24. Tone-quality	−033	−039	002	127	−054	−046	−043	−093
25. Tone-intensity	−027	−023	−012	015	−000	−119	−025	016

26. Tonal movement	011	008	−024	157	−000	−082	−014	−096
27. Tone-time interval	−078	000	−020	074	−028	−021	−038	018
28. Rhythm	−021	047	030	187	−001	−130	−031	028
29. Pitch	−051	003	063	146	−005	−101	−091	000
30. Musical taste	021	031	012	070	−037	−158	−129	−021
31. School adjustment and morale	−004	010	117	022	−035	021	−186	−148
32. Scholarly values	019	−017	022	050	034	085	−051	−027
33. Mechanics of study	−079	063	058	020	−057	−011	−146	−009
34. Effective study plan	−089	−057	−024	002	002	031	−157	−018
35. Outdoor interest	−413	−050	−223	−226	−126	−395	057	−052
36. Mechanical interest	−190	−137	−348	−247	−337	−244	112	042
37. Computational interest	−233	−284	−032	−155	−290	329	030	035
38. Science interest	−372	−366	−178	−318	−123	−270	−040	012
39. Persuasive interest	---	009	159	068	042	183	029	048
40. Artistic interest	009	---	−037	073	−087	−080	015	−022
41. Literary interest	159	−037	---	134	−140	052	−126	−043
42. Musical interest	068	073	134	---	−035	081	−028	−081
43. Social service interest	042	−087	−140	−035	---	−031	036	014
44. Clerical interest	183	−080	052	081	−031	---	086	072
45. School problems	029	015	−126	−028	036	086	---	465
46. Postgraduation anxieties	048	−022	−043	−081	014	072	465	---
47. Problems with self	−035	067	−028	−035	044	027	611	461
48. Problems with others	−072	061	−112	−072	083	039	642	564
49. Home-family problems	036	126	042	−008	027	−006	396	318
50. Boy-girl problems	−002	067	−081	−027	125	060	459	575
51. Health problems	004	058	−003	−010	082	055	434	437
52. Conflict-values	005	−006	009	−015	193	−079	434	486
53. Music appreciation	−041	084	077	138	−023	−131	−129	−030
54. Chronological age	006	−134	−072	−078	063	−076	023	001

Table 4.—Correlation matrix for the total high school sample, N=400—Continued

Variable	47	48	49	50	51	52	53	54
S. Speed of Reading	−100	−113	−018	−072	−029	−009	161	−081
P. Power of Reading	−049	−046	005	−037	−013	035	246	−017
1. Visual verbal meaning	−096	−118	024	−118	−026	−017	246	−008
2. Spatial relations	−049	−046	025	−089	−025	−100	146	−035
3. Inductive reasoning	−091	−031	−003	−109	−020	−093	272	−078
4. Work fluency	−045	−079	−018	−049	015	−022	136	063
5. Speed of addition	−114	−115	−025	−139	−075	−088	203	120
6. Mechanical aptitude	−109	−022	−028	−064	−022	−083	105	−010
7. Verbal analogies	−106	−074	−010	−126	−129	−089	217	−081
8. Vocabulary in context	−092	−079	−012	−078	−045	−014	233	−081
9. Vocabulary in isolation	−079	−094	011	−074	−051	003	264	−046
10. Range of information	−084	−071	030	−045	−062	−008	200	−116
11. Phonetic association	−118	−134	013	−034	−058	−031	258	−022
12. Word sense	−095	−103	000	−044	−054	−006	261	057
13. Homonymic meaning	−102	−127	−022	−112	−025	−032	190	013
14. Prefixes	−100	−073	−037	−105	−048	−024	188	104
15. Suffixes	−035	−019	009	−068	050	−028	037	097
16. Latin and Greek roots	−109	−085	−031	−105	−024	−028	141	091
17. Visual spelling recognition	−136	−155	−039	−116	−036	−056	146	022
18. Dot figure and ground	−108	−096	064	−156	−066	−063	131	−049
19. Cue-symbol closure	−107	−065	009	−128	−097	−103	157	041
20. Work embedded	−064	−091	029	−148	−018	−049	152	114
21. Perception of reversals	−194	−149	−075	−151	−065	−102	180	150
22. Auding	−112	−091	−006	−102	−075	−048	279	−071
23. Tonal memory	−083	−046	−021	−095	−015	−024	372	−108
24. Tone-quality	−033	−015	003	006	016	007	309	−053
25. Tone-intensity	045	030	010	000	059	064	275	−023

26. Tonal movement	−025	−016	−006	−048	−037	−019	334	−084
27. Tone-time interval	015	−007	029	−030	−010	−019	273	032
28. Rhythm	019	005	−045	065	038	062	324	006
29. Pitch	−062	−035	007	−015	−046	019	377	−054
30. Musical taste	−023	−068	−002	−065	−035	−031	513	025
31. School adjustment and morale	−185	−120	−028	−097	−146	−071	048	−113
32. Scholarly values	−050	−030	−031	−040	−085	−007	024	−031
33. Mechanics of study	−115	−082	−087	−028	−098	−003	078	−019
34. Effective study plan	−026	−060	−022	−039	−075	000	−011	003
35. Outdoor interest	017	031	017	−032	−083	−004	−049	015
36. Mechanical interest	−024	029	−021	−025	−067	−073	−083	057
37. Computational interest	−045	−009	−054	−026	−055	−115	−159	020
38. Science interest	−061	−055	−025	−054	−053	004	−004	016
39. Persuasive interest	−035	−072	036	−002	004	005	−041	006
40. Artistic interest	067	061	126	067	058	−006	084	−134
41. Literary interest	−028	−112	042	−081	−003	009	077	−072
42. Musical interest	−035	−072	−008	−027	−010	−015	138	−078
43. Social service interest	044	083	027	125	082	193	−023	063
44. Clerical interest	027	039	−006	060	055	−079	−131	−076
45. School problems	611	642	396	459	434	434	−129	023
46. Postgraduation anxieties	461	564	318	575	437	486	−030	001
47. Problems with self	---	748	526	525	574	501	−020	010
48. Problems with others	748	---	493	687	599	594	−046	−031
49. Home-family problems	526	493	---	376	465	412	−034	−066
50. Boy-girl problems	525	687	376	---	581	652	−043	−080
51. Health problems	574	599	465	581	---	583	−062	000
52. Conflict-values	501	594	412	652	583	---	−043	027
53. Music appreciation	−020	−046	−034	−043	−062	−043	---	029
54. Chronological age	010	−031	−066	−080	000	027	029	---

Reference to table 4, column S reveals that visual verbal meaning has the highest zero-order correlation with Speed of Reading ($r = 0.656$). Therefore, in our battery, visual verbal meaning is the most valid predictor of Speed of Reading, and will be selected as the first predictor test by the Wherry-Doolittle test selection method. Since r^2 in this case equals 0.43, visual verbal meaning cannot account for more than 43 percent of the criterion's variance. But 43 percent is a gross overestimate which needs to be corrected both in terms of the other predictors which the method will select and also the bias inherent in the procedure of selecting out of a random selection of "independent variables" that which is the most valid. In more specific terms, the probability is indeed great that when the contributions to variance are computed, visual verbal meaning will account for much less of the variance in Speed of Reading. The reason is that, when the beta weights are calculated for it and for the other variables which also make independent contributions to the variance of the criterion, they will draw from visual verbal meaning much of the variance which this "most valid" predictor appears, by virtue of being selected first, to account for in the criterion. Therefore, in terms of the Substrata-Factor Theory, the immediate problem is to discover *which* of the many variables in the matrix will be selected along with visual verbal meaning as those variables at *Level I* which have an independently *direct* and *joint* influence in the variation of high school students' scores on Speed of Reading. After the substrata components (factors) which make for diversity in Speed of Reading have been selected, the next step is to discover *how much* of the individual differences manifest in the criterion can be assigned to each of such selected, and therefore preferential, predictors.

Total Sample at Level I: Speed

Table 5 presents a summary of the substrata analysis at *Level I* in terms of the betas, cumulative $\bar{R}$'s and adjusted contributions which the six selected tests make to the variance in Speed of Reading. The zero-order r's are placed in the second column of the table to facilitate comparison. It should be recalled that these adjusted contributions to the variance in the criterion have been derived by multiplying each of the zero-order correlations by its appropriate beta weight and then adjusting the obtained figures in terms of the total shrunken $\bar{R}$ derived from the Wherry Shrinkage Formula.

The percent contributions listed in the right-hand column contain not only the *separate* coefficient of determination, but also one-half of the *shared* coefficient of determination. While the joint or shared variance can be calculated separately, they would answer a different question from the one posed: that is, how much of a criterion's variance can be attributed to the influence of each of the selected predictors? [1]

Scrutiny of table 5 shows that visual verbal meaning explains 17.9 percent of whatever it is that makes for individual differences in Speed of Reading among the 400 high school students used in this sample. Auding ability explains another 13.5 percent. In like manner, homonymic meaning explains another 9.2 percent; computational interest, 2.9 percent; inductive reasoning, 8.3 percent; and literary interest, 2.7 percent of the variance in Speed of Reading.

Table 5.—Substrata analysis of total sample yielding accounted-for variance in Speed of Reading

Criterion Level 0	Substrata factor Level I	Zero-order r	Beta β	Cumulative $\bar{R}$	Contribution to variance accounted for (in percent)	
					Adjusted	Total
Total (N=400)						
Speed of Reading	Visual verbal meaning	0.66	0.28	0.655	17.9	
	Auding	.60	.23	.697	13.5	
	Homonymic meaning	.58	.16	.714	9.2	
	Computational interest	—.23	—.12	.723	2.9	
	Inductive reasoning	.51	.16	.732	8.3	
	Literary interest	.26	.10	.738	2.7	54.5

In round numbers then, our six selected tests account for a little less than 54.5 percent of whatever it is that makes one high school student read faster or slower than another. Obviously the 45.5 percent of the variance not accounted for, in one sense, is as important as the 54.5 percent explained. Hypotheses on what other variables might be added to the battery to account for the 45.5 percent of the variance of Speed of Reading are discussed under "Implications" in the final chapter.

---

[1] From the above discussion it will be realized that each of the preferential predictors selected because it made an *independent* contribution to the variance of the criterion also entered into a *joint* relationship with other selected predictors to the end that each shared in what can be thought of as an additional contribution to the criterion's variance. This shared variance can be divided between the partners by prorating the total amount in terms of the coefficient of separate determination attributable to each, or by simply dividing the shared amount equally and assigning each half to the appropriate partners. The technique employed in the present study of multiplying the betas by the zero-order r's is tantamount to the latter alternative; that is, using the coefficient of separate determination plus one-half of the coefficient of shared determination in Wright's (1921) sense in order to account for the total influence (independent and shared) that a preferential predictor might exert on the criterion. *This is justified according to Ezekiel (1953), since these two methods have a mathematical equality.*

Necessity for Continuing the Substrata Analysis

If an experienced teacher or expert in the field of reading should take a critical look at the six preferential variables which according to the substrata analysis explain all the variance in Speed of Reading that can be accounted for by the 54 independent variables, he will surely object on the ground that the study has overlooked some other very important ones. It could be pointed out that only 54.5 percent of the variance in Speed of Reading has been accounted for and that one must look to other variables beyond those used in the present study for the other 45.5 percent. However, even this would not satisfy the expert teacher, for he would insist that he knows from experience that many of the variables included in the matrix, but not selected as making positive contributions to the criterion at *Level I*, are, in fact, important; and if the teacher presses the point, we would have to agree. In fact, it was this very objection that caused Holmes, in 1948, to develop the substrata-factor analysis technique. To be more specific, anyone who has taught reading knows that such variables as auditory and visual perception, knowledge of affixes and roots, the ability to see verbal relationships, etc., must play a part in reading for speed at the high school level. Nevertheless, the tests in the battery which assess these very areas were not selected to account for Speed of Reading beyond those six preferential ones already named. The question is, Why? Statistically, virtually all the variance in Speed of Reading that can be accounted for by the total matrix has been explained by the particular six variables selected. The question remains, Just how do these other variables that the reading teacher believes to be important to Speed of Reading actually fit into the picture?

To resolve this apparent paradox the assumption is made, in accordance with the Substrata-Factor Theory of Reading, that while the six preferential predictors enter into a *direct* relationship (separately and jointly) with the criterion, Speed of Reading, other important variables may also function in the general working-system by asserting an *indirect* influence on the criterion from a more remote level. The substrata analysis, therefore, extends the Wherry-Doolittle technique to successive levels. Each of the predictor variables will now be considered as a possible subcriterion, and in order to explain individual differences in each a search at *Level II* will be made among the remaining variables in the matrix for those which might help to account for the variance in each of the six already selected at *Level I*.

Total Sample at Level II: Speed

Table 6 gives the results of the systematic matrix reduction at *Level II* for each of the subcriteria at *Level I.*

Visual Verbal Meaning. Reference to visual verbal meaning in table 6 makes it apparent that 64 percent of whatever it is that makes for individual differences in the ability to discriminate verbal meanings visually can be prorated to the following extent: word sense, 20.6 percent; vocabulary in context, 16 percent; dot ground, 7.6 percent; tonal movement, 3.7 percent; Latin roots, 6.8 percent; and range of information, 9.3 percent.

Auding. It will also be noted that vocabulary in context contributes 23.9 percent by way of explaining individual differences in auding ability in this sample. Range of information contributes another 19.3 percent; prefixes, 7. 5 percent; verbal analogies, 11.1 percent; visual spelling recognition, —4.6 percent;[2] and finally, Latin and Greek roots make a contribution of 5.6 percent over and above the contributions made to the variance of auding by previously named variables. Together the six variables account for 62.8 percent of the variance of auding ability.

Homonymic Meaning. The analysis reveals that word sense accounts for 42 percent; spelling, 11.2 percent; Latin and Greek roots, 6.2 percent; spatial relations, 2.6 percent; and prefixes, 6.9 percent of whatever it is that makes for individual differences in homonymic meaning. Together these five variables contribute 68.9 percent to the variance of homonymic meaning.

Inductive Reasoning. Within the limits of our matrix, the "simplicity" of the task involved in the inductive reasoning test precludes further analysis. Therefore, this analysis is considered complete.

---

[2] Snedecor (1946) and Ezekiel (1953) give similar explanations of negative contributions to variance. Ezekiel writes:

> Off-hand it seems difficult to explain how the 'determination' of any variable can be less than nothing. . . . The explanation is simple, however. Although the total variation in the estimates of the dependent variables is obtained by adding the contributions of several independent variables, it does not follow that all variables will be influencing the estimate in the same direction at the same time—all tending to give low values when the actual value is low, or all tending to give high values when the actual value is high. It sometimes happens that one variable may tend to work counter to the other variables, usually preventing the final estimate from going so low as it otherwise would when the general effect is downward and tending to keep it from going so high as it otherwise would when the others are forcing it up. It is under such conditions that negative coefficients of separate determination are obtained; they do not mean that the variable has no significance, but that its influence is usually exerted counter to the influence of other variables.

Lubin (1957) states that given two predictor variables *V* and *X*, where the validity of *V* is higher than that of *X*, then subtracting X from *V* will give a difference score *D*, such that $r_{dc} > r_{vc}$ when the following equation obtains:

$$r_{xv} > \frac{1}{2}\left[\sigma_x/\sigma_v + 2r_{xc}/r_{vc} - (r^2_{xc}/r^2_{vc})\,\sigma_x/\sigma_y\right]$$

Under these conditions . . . " X acts as if it were a suppressor" (p. 292).

Table 6.—Substrata analysis of total sample yielding accounted-for variance in Level I substrata factors underlying Speed

Substrata factor Level I	Predictor Level II	Zero-order r	Beta β	Cumulative $\overline{R}$	Contribution to variance accounted for (in percent)	
					Adjusted	Total
Total (N=400)						
From Speed at Level 0 to—						
Visual verbal meaning	Word sense	0.69	0.30	0.685	20.6	
	Vocabulary in context	.68	.24	.758	16.0	
	Dot figure and ground	.47	.16	.779	7.6	
	Tonal movement	.35	.10	.788	3.7	
	Latin and Greek roots	.56	.12	.795	6.8	
	Range of information	.63	.15	.800	9.3	64.0
Auding	Vocabulary in context	.72	.34	.718	23.9	
	Range of information	.70	.28	.760	19.3	
	Prefixes	.49	.15	.776	7.5	
	Verbal analogies	.67	.17	.784	11.1	
	Visual spelling recognition	.33	−.14	.789	−4.6	
	Latin and Greek roots	.49	.12	.794	5.6	62.8
Homonymic meaning	Word sense	.79	.53	.793	42.0	
	Visual spelling recognition	.64	.18	.812	11.2	
	Latin and Greek roots	.60	.10	.822	6.2	
	Spatial relations	.28	.09	.826	2.6	
	Prefixes	.60	.11	.829	6.9	68.9
Computational interest	(Analysis completed.)					
Inductive reasoning	(Analysis completed.)					
Literary interest	(Analysis completed.)					

Literary and Computational Interest. Since, at *Level I*, literary interest makes a small positive contribution and computational interest makes a small negative or suppressor-like contribution to the variance of Speed of Reading, it was deemed inadvisable to pursue further the factors which might underlie these two interest variables.

It may be seen from table 6 that (*a*) things are beginning to appear more complicated, and (*b*) that a few variables have been precipitated more than once at *Level II*. Therefore, by capitalizing on (*b*) a model may be constructed which should reduce the amount of apparent complexity mentioned in (*a*).

Figure 4, therefore, presents a model which gives a more parsimonious substrata-factor interpretation to the important facts presented in tables 5 and 6.

A general perusal of figure 4 will show that some of the variables at *Level II* underlie more than one subcriterion at *Level I*. It is to be expected, therefore, that when the substrata analysis is extended, identical results will be obtained at *Level III* for identical subcriteria at *Level II*. The analysis to be reported in the following paragraphs proved this to be precisely the case; and therefore, the predictor variables

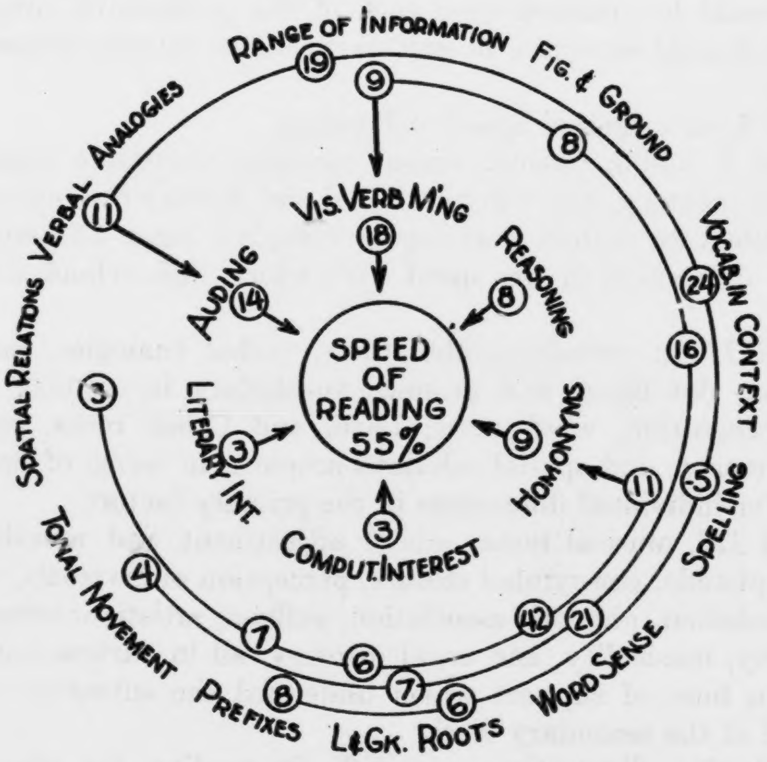

RANGE OF INFORMATION
19
9
FIG. & GROUND
8
VERBAL ANALOGIES
11
VIS. VERB M'NG
18
AUDING
14
REASONING
8
VOCAB. IN CONTEXT
24
16
SPEED OF READING 55%
SPATIAL RELATIONS
3
LITERARY INT.
3
HOMONYMS
9
11
-5
SPELLING
3
COMPUT. INTEREST
TONAL MOVEMENT
4
7
6
42
21
WORD SENSE
PREFIXES
8
7
6
L & GK. ROOTS

Figure 4.—Concentric flowchart for Speed of Reading for total sample of 400 high school students (a).

at *Level III* for the same subcriterion occurring more than once at *Level II* are reported only once. A case in point may be used as an illustration: The substrata analysis indicated that (*a*) underlying visual verbal meaning at *Level I*, among other elements at *Level II*, was word sense; and likewise, that (*b*) underlying homonymic meaning at *Level I*, among other elements, was that of word sense. The complete analysis reveals that in both cases the elements at *Level III* and their contributions to the variance of word sense at *Level II* were identical. The model given in figure 4 lends itself admirably to this consolidating process.

Table 7 shows the result of analyzing the predictor variables at *Level II* as subcriteria to discover those variables which underlie them at *Level III*. The overall picture is given in figure 5 in the Summary for Speed of Reading.

Summary for Speed of Reading: Total Sample

The results of the substrata analysis for Speed of Reading are shown in figure 5. The concentric rings from the central target area outward represent the hierarchical organization of the substrata factors discovered at *Levels I*, *II*, and *III* in the working-system for Speed of Reading. The disks contain the percent variance accounted for and should be summed over each of the preferential predictors that are indicated as active in any particular substrata factor's line of support.

At *Level 0*, on target, is Speed of Reading.

At *Level I*, auding, visual verbal meaning, inductive reasoning, homonymic meaning, and computational and literary interest are the primary substrata factors that together explain some 55 percent of individual differences in the speed with which high school students can read.

At *Level II*, in various combinations, verbal analogies, range of information, dot figure and ground, vocabulary in context, visual spelling recognition, word sense, Latin and Greek roots, prefixes, tonal movement, and spatial relations account, in terms of Speed of Reading, for individual differences in the primary factors.

At *Level III*, musical taste, school adjustment and morale, mechanical aptitude, cue-symbol closure, perception of reversals, vocabulary in isolation, phonetic association, suffixes, artistic interest, age, tone-quality, musicality, and tonal memory, all in various combinations, form lines of support which undergird the substrata factors discovered at the secondary level.

The following illustration may help in reading the chart. At *Level II*, 65 percent (5+56+3+1) of range of information is undergirded by mechanical aptitude, vocabulary in isolation, suffixes, and

Table 7.—Substrata analysis of total sample yielding accounted-for variance in Level II substrata factors underlying Speed

Substrata factor Level II	Predictor Level III	Zero-order r	Beta β	Cumulative $\overline{R}$	Contribution to variance accounted for (in percent)	
					Adjusted	Total
Total (N=400)						
From Speed Through Visual Verbal Meaning at Level I to—						
Word sense	Phonetic association	0. 87	0. 73	0. 872	63. 3	
	Vocabulary in isolation	. 61	. 17	. 885	10. 6	
	Suffixes	. 50	. 11	. 892	5. 7	
	Chronological age	. 06	. 07	. 894	. 4	80. 0
Vocabulary in context	Vocabulary in isolation	. 85	. 83	. 852	71. 0	
	Perception of reversals	. 26	. 09	. 857	2. 4	73. 4
Dot figure and ground	(Analysis completed.)					
Tonal movement	Tonal memory	. 46	. 29	. 453	12. 9	
	Tone-quality	. 41	. 25	. 518	10. 1	
	Musical appreciation	. 33	. 14	. 533	4. 7	
	School adjustment and morale	. 18	. 12	. 546	2. 1	29. 8
Latin and Greek roots	Phonetic association	. 52	. 27	. 515	13. 5	
	Suffixes	. 47	. 25	. 580	11. 6	
	Vocabulary in isolation	. 47	. 21	. 612	9. 5	
	Artistic interest	—. 10	—. 14	. 622	1. 3	
	Cue-symbol closure	. 32	. 12	. 631	3. 7	39. 6
Range of information	Vocabulary in isolation	. 79	. 72	. 794	56. 5	
	Mechanical aptitude	. 39	. 13	. 805	5. 2	
	Chronological age	—. 12	—. 09	. 808	1. 1	
	Suffixes	. 34	. 09	. 813	3. 2	66. 0

Table 7.—Substrata analysis of total sample yielding accounted-for variance in Level II substrata factors underlying Speed—Continued

Substrata factor Level II	Predictor Level III	Zero-order r	Beta β	Cumulative $\overline{R}$	Contribution to variance accounted for (in percent)	
					Adjusted	Total
	From Speed Through Auding at Level I to—					
Vocabulary in context	Vocabulary in isolation	0.85	0.83	0.852	71.0	
	Perception of reversals	.26	.09	.857	2.4	73.4
Range of information	Vocabulary in isolation	.79	.72	.794	56.5	
	Mechanical aptitude	.39	.13	.805	5.2	
	Chronological age	−.12	−.09	.808	1.1	
	Suffixes	.34	.09	.813	3.2	66.0
Prefixes	(Analysis completed.)					
Verbal analogies	Vocabulary in isolation	.69	.55	.694	38.2	
	Mechanical aptitude	.40	.15	.717	5.9	
	Musical taste	.27	.13	.728	3.6	
	Cue-symbol closure	.40	.12	.736	4.8	
	School adjustment and morale	.25	.11	.743	2.8	55.3
Visual spelling recognition	Phonetic association	.63	.43	.631	27.1	
	Perception of reversals	.49	.31	.691	15.0	
	Vocabulary in isolation	.45	.19	.702	8.7	
	Mechanical aptitude	.05	−.12	.710	.5	50.3

Latin and Greek roots	Phonetic association	.52	.27	.515	13.5	
	Suffixes	.47	.25	.580	11.6	
	Vocabulary in isolation	.47	.21	.612	9.5	
	Artistic interest	−.10	−.14	.622	1.3	
	Cue-symbol closure	.32	.12	.631	3.7	39.6

From Speed Through Homonymic Meaning at Level I to—						
Word sense	Phonetic association	0.87	0.73	0.872	63.3	
	Vocabulary in isolation	.61	.17	.885	10.6	
	Suffixes	.50	.11	.892	5.7	
	Chronological age	.06	.07	.894	.4	80.0
Visual spelling recognition	Phonetic association	.63	.43	.631	27.1	
	Perception of reversals	.49	.31	.691	15.0	
	Vocabulary in isolation	.45	.19	.702	8.7	
	Mechanical aptitude	.05	−.12	.710	−.5	50.3
Latin and Greek roots	Phonetic association	.52	.27	.515	13.5	
	Suffixes	.47	.25	.580	11.6	
	Vocabulary in isolation	.47	.21	.612	9.5	
	Artistic interest	−.10	−.14	.622	1.3	
	Cue-symbol closure	.32	.12	.631	3.7	39.6
Spatial relations	(Analysis completed.)					
Prefixes	(Analysis completed.)					

chronological age. Likewise, 65 percent (9+8+16+21+7+4) of visual verbal meaning at *Level I* is explained by range of information, dot figure and ground, vocabulary in context, word sense, Latin and Greek roots, and tonal movement. Finally, 55 percent (18+8+9+3+3+14) of Speed of Reading may be accounted for in terms of the following primary substrata factors: Visual verbal meaning, inductive reasoning, homonymic meaning, computational interest, literary interest, and auding.

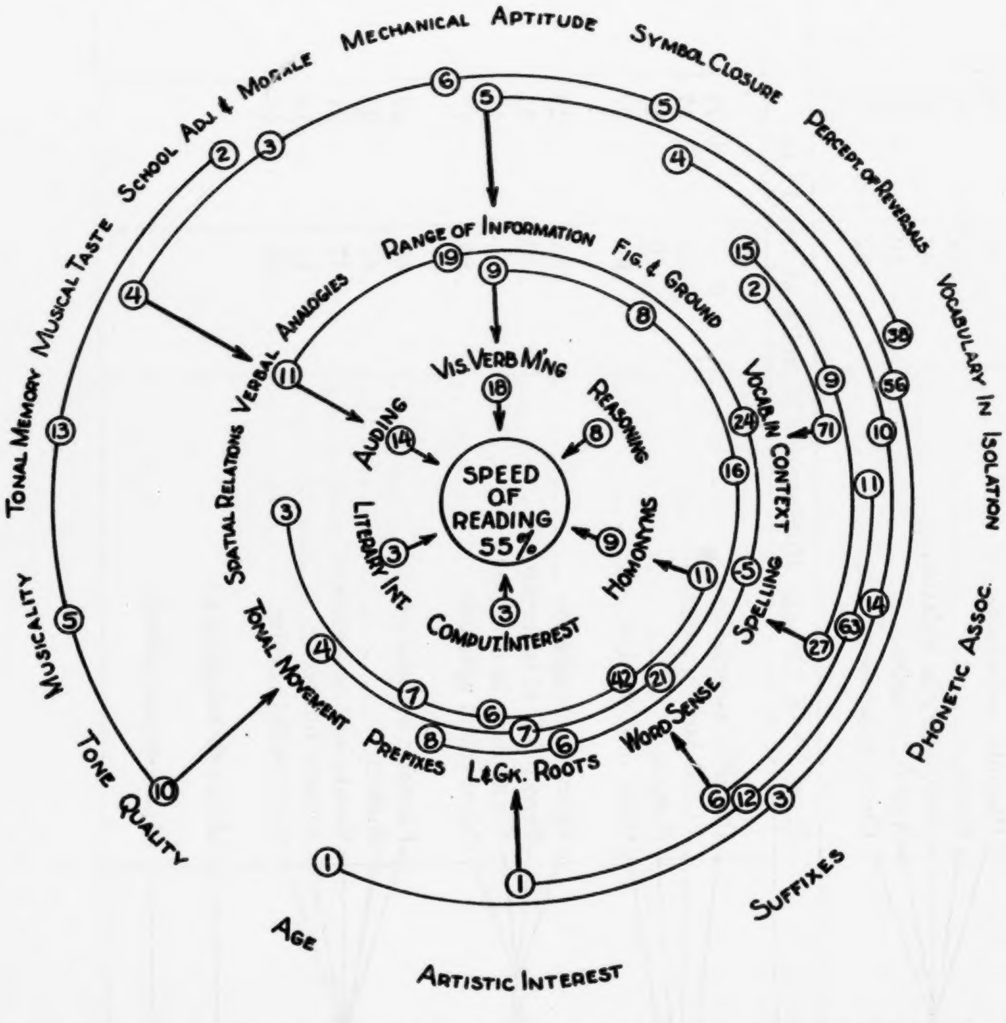

Mechanical Aptitude
Symbol Closure
Percept. of Reversals
Vocabulary In Isolation
Phonetic Assoc.
Suffixes
Artistic Interest
Age
Tone Quality
Musicality
Tonal Memory
Musical Taste
School Adj. & Morale
Range of Information
Fig. & Ground
Vocab. in Context
Spelling
Word Sense
L&Gk. Roots
Prefixes
Tonal Movement
Spatial Relations
Verbal Analogies
Vis. Verb M'ng
Reasoning
Homonyms
Comput. Interest
Literary Int.
Auding
Speed of Reading 55%
6
5
5
4
2
3
4
19
9
8
15
2
38
56
10
11
9
71
24
16
18
8
14
11
3
9
3
3
11
5
27
63
14
4
7
6
7
6
8
42
21
6
12
3
1
1
13
5
10

Figure 5.—Concentric flowchart for Speed of Reading for total sample of 400 high school students (b).

Part II. Substrata Analysis for Power of Reading: Total Sample

Table 4, part I of this chapter, indicates that the second criterion variable is Power of Reading and, furthermore, that the largest zero-order correlation in the *P* column is between Power of Reading and vocabulary in context (r=0.785). Vocabulary in isolation, auding ability, range of information, verbal analogies, and visual verbal meaning all follow in close array (r's=0.779, 0.745, 0.742, 0.727, and 0.671). The rest of the independent variables arrange themselves in an orderly way with a further gradual decrease in the increment of the r's. School problems and Power of Reading correlate with an r of −0.221, thus indicating that the more powerful reader tends to have fewer school difficulties. However, the question remains, which of these variables make independent contributions to the variance of reading and which do not? That is, that primary team of tests which constitutes the most efficient set of preferential predictors for Power of Reading must be systematically extracted. As indicated before, this is accomplished by a Wherry-Doolittle multiple-regression analysis in which the preferential predictors are selected and the R is adjusted by means of the Wherry Shrinkage Formula to overcome selection bias. Likewise, as was done for Speed of Reading, the Wherry-Doolittle is extended to a substrata analysis in order to tease out those secondary and tertiary variables which underlie the primary predictors.

Total Sample at Level I: Power

Reference to table 8 indicates that vocabulary in context, the first independent variable selected, contributes 15.9 percent to Power of Reading. Auding is next selected, and it makes a contribution of 15.9 percent over and above that made by vocabulary in context. Holding these two variables constant, the method selects verbal analogies as the third factor, contributing 16.2 percent to the criterion. Vocabulary in isolation contributes 15.7 percent, followed by visual verbal meaning, which contributes a further 6 percent. Mechanical interest contributes 0.8 percent. Tone-intensity contributes 3.2 percent, and finally, effective study planning and deliberation contributes 0.9 percent to whatever it is that makes high school students differ from one another in their ability to read with power. Out of a pool of 54 tests, which on the basis of the reviewed literature were pertinent to reading success, only 8 were selected as making a *direct* (independent and joint) contribution of 74.6 percent to the variance of Power of Reading.

Total Sample at Level II: Power

Table 9 and figure 6 present the results of the Wherry-Doolittle-Holmes substrata analysis at *Level II* for the subcriteria found to underlie Power of Reading at *Level I*.

Vocabulary in Context. Table 9 indicates that the first selected variable, range of information, contributes 42.6 percent to the variance

Table 8.—Substrata analysis of total sample yielding accounted-for variance in Power of Reading

Criterion Level 0	Substrata factor Level I	Zero-order r	Beta β	Cumulative $\bar{R}$	Contribution to variance accounted for (in percent)	
					Adjusted	Total
Total (N=400)						
Power of Reading	Vocabulary in context	0. 78	0. 20	0. 784	15. 9	
	Auding	. 74	. 21	. 826	15. 9	
	Verbal analogies	. 73	. 22	. 841	16. 2	
	Vocabulary in isolation	. 78	. 20	. 850	15. 7	
	Visual verbal meaning	. 67	. 09	. 855	6. 0	
	Mechanical interest	−. 09	−. 09	. 858	. 8	
	Tone-intensity	. 36	. 09	. 861	3. 2	
	Effective study plan	. 12	. 07	. 863	. 9	74. 6

of vocabulary in context. Word sense is selected next and contributes an additional 13.3 percent. Computational interest comes out next with a 2.4 percent contribution. Finally, inductive reasoning contributes 5.3 percent. Thus, these four variables make a total contribution of 63.6 percent to the variance of vocabulary in context.

Auding. The largest contributor to auding ability is range of information, which accounts for 36.3 percent of its variance. The substrata analysis shows that prefixes further account for 7.1 percent; inductive reasoning, 8.0 percent; musical appreciation, 3.1 percent; speed of addition, −1.8 percent in a suppressor effect; and Latin and Greek roots, 5.7 percent of individual differences in auding at the high school level.

Verbal Analogies. The important variables underlying verbal analogies, with their percent contribution to variance, are: Range of information, 37.9 percent; inductive reasoning, 9.5 percent; clerical interest, 3.1 percent; musical taste, 2.9 percent; school adjustment and morale, 2.4 percent; and spatial relations, 3.8 percent.

Vocabulary in Isolation. Range of information and word sense contribute 52.4 percent and 13.8 percent, respectively, to the variance of vocabulary in isolation. Computational interest contributes another 1.6 percent.

Visual Verbal Meaning. Visual verbal meaning is most strongly undergirded by word sense and range of information. These two predictors account for 22.0 percent and 16.4 percent of the variance of this subcriterion. Dot figure and ground, inductive reasoning, and Latin and Greek roots contribute 7.6, 5.8, and 5.9 percent, respectively, whereas literary interest and tonal movement make smaller, but significant, contributions of 2.6 and 3.2 percent to the variance of visual verbal meaning.

Tone-Intensity, Mechanical Interest, Effective Study Planning and Deliberation. The analyses for these are complete.

Figure 6, page 76, illustrates the relationships at the primary and secondary levels for the Power of Reading model.

Total Sample at Level III: Power

In accordance with the Substrata-Factor Theory, the preferential predictors for Power of Reading at *Level 0*, i.e., *Level I* and *Level II*, have been selected. The remaining variables in the matrix are now analyzed to discover those that might best be thought of as accounting for the subcriteria in *Level II*. Table 10 presents the results of the *Level III* analysis.

Table 9.—Substrata analysis of total sample yielding accounted-for variance in Level I substrata factors underlying Power

Substrata factor Level I	Predictor Level II	Zero-order r	Beta β	Cumulative $\overline{R}$	Contribution to variance accounted for (in percent)	
					Adjusted	Total
Total (N=400)						
From Power at Level 0 to—						
Vocabulary in context	Range of information	0. 75	0. 57	0. 749	42. 6	
	Word sense	. 61	. 22	. 784	13. 3	
	Computational interest	−. 21	−. 11	. 791	2. 4	
	Inductive reasoning	. 47	. 11	. 797	5. 3	63. 6
Auding	Range of information	. 70	. 52	. 705	36. 3	
	Prefixes	. 49	. 15	. 737	7. 1	
	Inductive reasoning	. 47	. 17	. 750	8. 0	
	Musical appreciation	. 28	. 11	. 754	3. 1	
	Speed of addition	. 15	−. 12	. 760	−1. 8	
	Latin and Greek roots	. 49	. 12	. 764	5. 7	58. 4
Verbal analogies	Range of information	. 71	. 54	. 709	37. 9	
	Inductive reasoning	. 51	. 19	. 745	9. 5	
	Clerical interest	−. 25	−. 12	. 757	3. 1	
	Musical taste	. 27	. 11	. 762	2. 9	
	School adjustment and morale	. 25	. 09	. 767	2. 4	
	Spatial relations	. 38	. 10	. 771	3. 8	59. 6

Vocabulary in isolation	Range of information	.79	.66	.794	52.4	
	Word sense	.61	.23	.819	13.8	
	Computational interest	−.19	−.08	.823	1.6	67.8
Visual verbal meaning	Word sense	.69	.32	.685	22.0	
	Range of information	.63	.26	.750	16.4	
	Dot figure and ground	.47	.16	.773	7.6	
	Inductive reasoning	.53	.11	.782	5.8	
	Literary interest	.24	.11	.789	2.6	
	Latin and Greek roots	.56	.11	.793	5.9	
	Tonal movement	.35	.09	.797	3.2	63.5
Tone-intensity	(Analysis completed.)					
Mechanical interest	(Analysis completed.)					
Effective study plan	(Analysis completed.)					

Table 10.—Substrata analysis of total sample yielding accounted-for variance in Level II substrata factors underlying Power

Substrata factor Level II	Predictor Level III	Zero-order r	Beta β	Cumulative $\bar{R}$	Contribution to variance accounted for (in percent)	
					Adjusted	Total
Total (N=400)						
From Power through Vocabulary in Context at Level I to—						
Range of information	Homonymic meaning	0. 50	0. 28	0. 495	13. 7	
	Mechanical aptitude	. 39	. 28	. 576	10. 6	
	Phonetic association	. 47	. 19	. 595	8. 7	
	Pitch	. 30	. 12	. 604	3. 3	
	Chronological age	−. 12	−. 11	. 613	1. 2	37. 5
Word sense	Phonetic association	. 87	. 61	. 872	53. 4	
	Homonymic meaning	. 79	. 32	. 906	25. 7	
	Chronological age	. 06	. 06	. 908	. 4	
	Suffixes	. 50	. 06	. 910	3. 3	82. 8
Computational interest	(Analysis completed.)					
Inductive reasoning	(Analysis completed.)					
From Power Through Auding at Level I to—						
Range of information	Homonymic meaning	0. 50	0. 28	0. 495	13. 7	
	Mechanical aptitude	. 39	. 28	. 576	10. 6	
	Phonetic association	. 47	. 19	. 595	8. 7	
	Pitch	. 30	. 12	. 604	3. 3	
	Chronological age	−. 12	−. 11	. 613	1. 2	37. 5

Prefixes	(Analysis completed.)					
Inductive reasoning	(Analysis completed.)					
Musical appreciation	Pitch	. 38	. 21	. 374	7. 8	
	Tonal memory	. 37	. 22	. 437	8. 2	
	Rhythm	. 32	. 16	. 460	5. 2	21. 2
Speed of addition	(Analysis completed.)					
Latin and Greek roots	Homonymic meaning	. 60	. 36	. 598	21. 2	
	Suffixes	. 47	. 20	. 633	9. 6	
	Visual spelling recognition	. 49	. 18	. 643	8. 8	
	Mechanical aptitude	. 26	. 13	. 655	3. 4	43. 0
From Power Through Verbal Analogies at Level I to—						
Range of information	Homonymic meaning	0. 50	0. 28	0. 495	13. 7	
	Mechanical aptitude	. 39	. 28	. 576	10. 6	
	Phonetic association	. 47	. 19	. 595	8. 7	
	Pitch	. 30	. 12	. 604	3. 3	
	Chronological age	—. 12	—. 11	. 613	1. 2	37. 5
Inductive reasoning	(Analysis completed.)					
Clerical interest	(Analysis completed.)					
Musical taste	Pitch	. 42	. 27	. 415	10. 8	
	Tonal memory	. 34	. 14	. 450	4. 6	
	Work fluency	. 26	. 15	. 473	3. 7	
	Tone-quality	. 34	. 14	. 486	4. 6	23. 7
School adjustment and morale	(Analysis completed.)					
Spatial relations	(Analysis completed.)					

Table 10.—Substrata analysis of total sample yielding accounted-for variance in Level II substrata factors underlying Power—Continued

Substrata factor Level II	Predictor Level III	Zero order r	Beta β	Cumulative $\overline{R}$	Contribution to variance accounted for (in percent)	
					Adjusted	Total
	From Power Through Vocabulary in Isolation at Level I to—					
Range of information	Homonymic meaning	0.50	0.28	0.495	13.7	
	Mechanical aptitude	.39	.28	.576	10.6	
	Phonetic association	.47	.19	.595	8.7	
	Pitch	.30	.12	.604	3.3	
	Chronological age	−.12	−.11	.613	1.2	37.5
Word sense	Phonetic association	.87	.61	.872	53.4	
	Homonymic meaning	.79	.32	.906	25.7	
	Chronological age	.06	.06	.908	.4	
	Suffixes	.50	.06	.910	3.3	82.8
Computational interest	(Analysis completed.)					
	From Power Through Visual Verbal Meaning at Level I to—					
Word sense	Phonetic association	0.87	0.61	0.872	53.4	
	Homonymic meaning	.79	.32	.906	25.7	
	Chronological age	.06	.06	.908	.4	
	Suffixes	.50	.06	.910	3.3	82.8

Range of information	Homonymic meaning	.50	.28	.495	13.7	
	Mechanical aptitude	.39	.28	.576	10.6	
	Phonetic association	.47	.19	.595	8.7	
	Pitch	.30	.12	.604	3.3	
	Chronological age	−.12	−.11	.613	1.2	37.5
Dot figure and ground	(Analysis completed.)					
Inductive reasoning	(Analysis completed.)					
Literary interest	(Analysis completed.)					
Latin and Greek roots	Homonymic meaning	.60	.36	.598	21.2	
	Suffixes	.47	.20	.633	9.6	
	Visual spelling recognition	.49	.18	.643	8.8	
	Mechanical aptitude	.26	.13	.655	3.4	43.0
Tonal movement	Tonal memory	.46	.30	.453	13.3	
	Tone-quality	.41	.23	.518	9.5	
	Pitch	.38	.14	.531	5.3	28.1

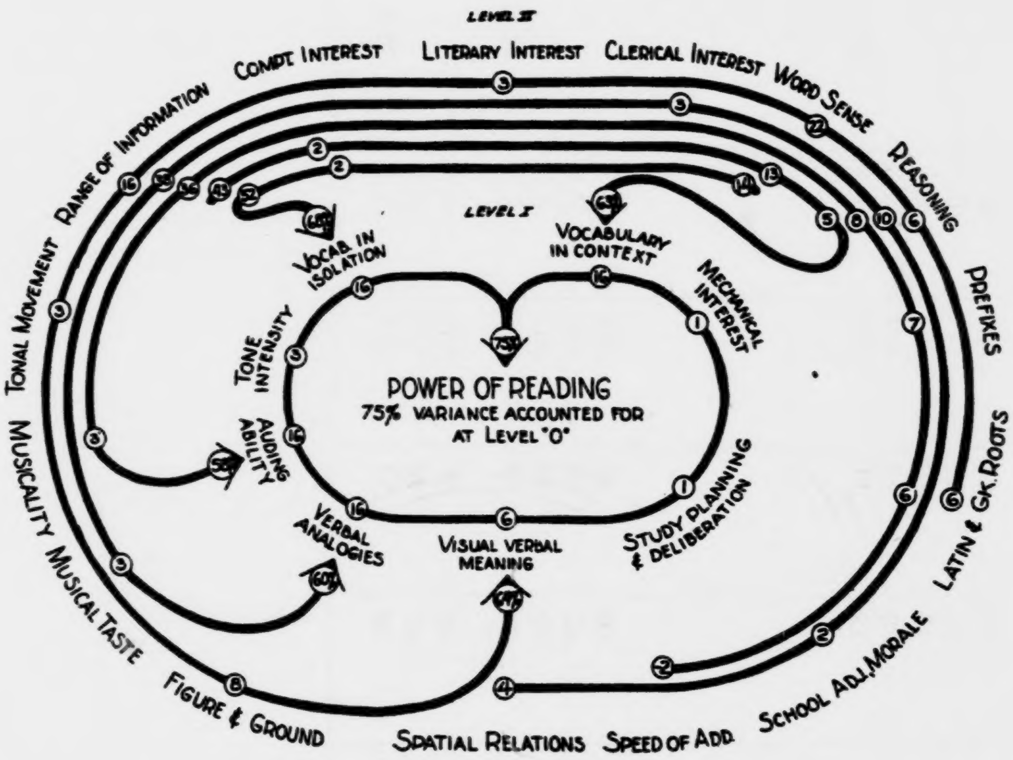

LEVEL II
COMPT. INTEREST
LITERARY INTEREST
CLERICAL INTEREST
WORD SENSE
REASONING
PREFIXES
LATIN & GK. ROOTS
SCHOOL ADJ. MORALE
SPEED OF ADD.
SPATIAL RELATIONS
FIGURE & GROUND
MUSICAL TASTE
MUSICALITY
TONAL MOVEMENT
RANGE OF INFORMATION
LEVEL I
VOCAB. IN ISOLATION
VOCABULARY IN CONTEXT
MECHANICAL INTEREST
STUDY PLANNING & DELIBERATION
VISUAL VERBAL MEANING
VERBAL ANALOGIES
AUDING ABILITY
TONE INTENSITY
POWER OF READING
75% VARIANCE ACCOUNTED FOR AT LEVEL "O"
75%
63%
65%
58%
60%
49%
16
16
16
16
6
1
1
3
3
3
22
2
2
16
38
36
43
52
14
13
5
8
10
6
7
6
6
2
2
4
8
5
3
5

Figure 6.—Concentric flowchart for Power of Reading for total sample of 400 high school students (a).

Summary for Power of Reading: Total Sample

The Concentric Flow Chart in figure 7 summarizes the results of the substrata analysis for Power of Reading. The rationale of the Substrata-Factor Theory may be nicely traced in the lines of support which tie together the successive substructural elements undergirding the audiovisual verbal-processing skill we call power-reading! On the concentric lines of support, the percent contributions which the elements make are designated. The total variance accounted for is also indicated within the arrowhead which impinges on its particular substrata factor in the next inner area.

1. *Level I.* Starting with Power of Reading at the center, it is noted that at *Level I* the *primary substrata factors*—vocabulary in context, mechanical interest, study planning, visual verbal meaning, verbal analogies, auding ability, tone intensity, and vocabulary in isolation—account for some 75 percent of whatever it is that makes individual high school students differ in their ability to read with power.

2. *Level II.* Likewise, by observing the specific contributions noted within the lines of support, it is evident that in various combinations the component subsystems at *Level II* account for 63 percent of vocab-

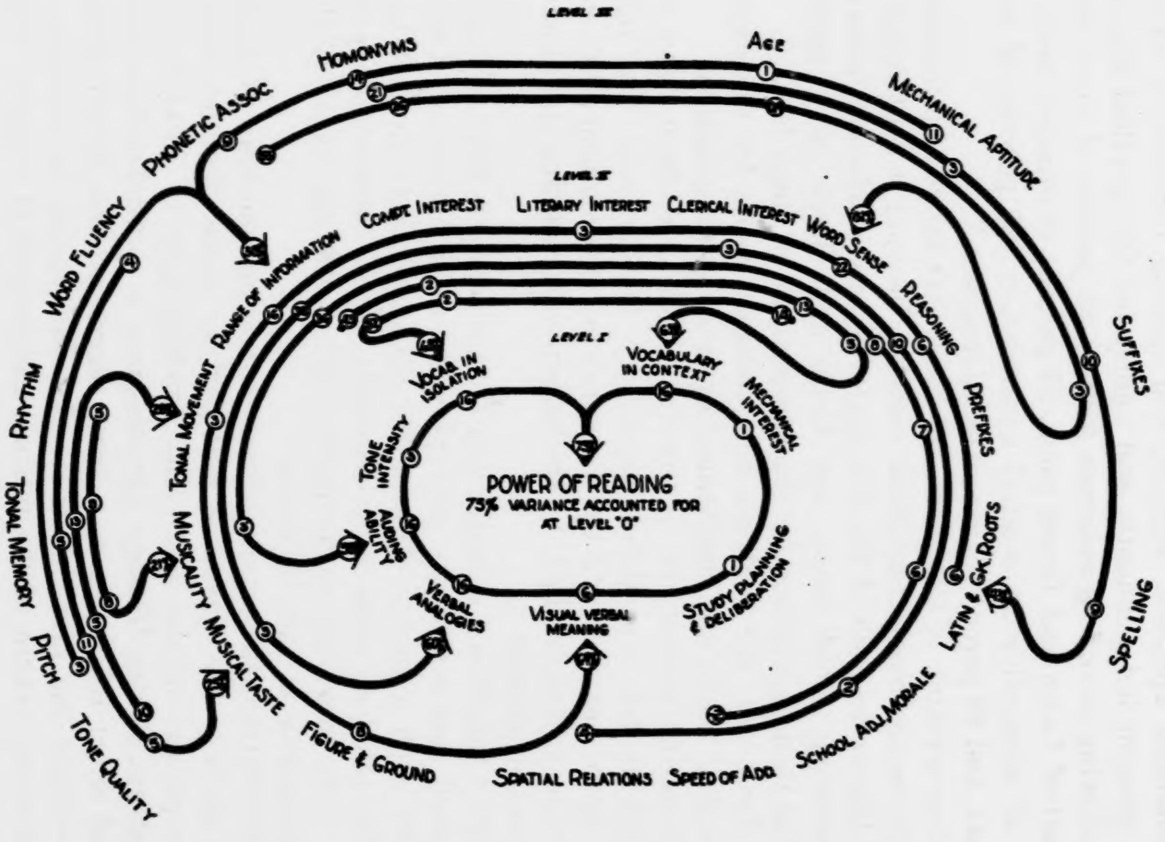

LEVEL III
HOMONYMS
AGE
MECHANICAL APTITUDE
PHONETIC ASSOC.
WORD FLUENCY
LEVEL II
COMP'T INTEREST
LITERARY INTEREST
CLERICAL INTEREST
WORD SENSE
RANGE OF INFORMATION
REASONING
SUFFIXES
LEVEL I
VOCAB. IN ISOLATION
VOCABULARY IN CONTEXT
MECHANICAL INTEREST
PREFIXES
RHYTHM
TONAL MOVEMENT
TONE INTENSITY
POWER OF READING
75% VARIANCE ACCOUNTED FOR AT LEVEL "O"
TONAL MEMORY
MUSICALITY
AUDING ABILITY
LATIN & GK. ROOTS
STUDY PLANNING & DELIBERATION
VERBAL ANALOGIES
VISUAL VERBAL MEANING
PITCH
MUSICAL TASTE
SPELLING
SCHOOL ADJ. MORALE
TONE QUALITY
FIGURE & GROUND
SPATIAL RELATIONS
SPEED OF ADD.

Figure 7.—Concentric flowchart for Power of Reading for total sample of 400 high school students (b).

ulary in context, 64 percent of visual verbal meaning, 60 percent of verbal analogies, 58 percent of auding ability, and 68 percent of vocabulary in isolation.

3. *Level III.* Finally, observation of the outermost ring makes it evident that the elements of tone-quality, pitch, tonal memory, rhythm, word fluency, phonetic association, homonymic meaning, age, mechanical aptitude, suffixes, and spelling combine in various ways to account independently and jointly for the specified amounts of the following *secondary substrata factors:* 82 percent of word sense, 43 percent of Latin and Greek roots, 25 percent of musical taste, 21 percent of musicality or musical appreciation, 28 percent of tonal movement, and 38 percent of range of information.

4. A close scrutiny of the chart will show that range of information appears to be the most ubiquitous variable, because it contributes in varying degrees to each of the five major *primary substrata factors.*

5. Reasoning, word sense, and Latin and Greek roots carry a substantial load accounting for the composition of these factors.

6. At *Level III*, the multiple contributions made by homonyms, tonal memory, pitch, and mechanical aptitude are impressive.

7. The specific magnitudes of the contributions made at *Level I* by the auding factor, the three vocabulary factors, and the verbal analogy factor, at *Level II* by the range of information and word sense factors, and at *Level III* by the homonymic meaning and phonetic factors are substantial.

8. A truly significant contribution of this study is the pinpointing of the small but important part played in the Power of Reading process by such auditory elements as tone-intensity, musical taste, musicality, tonal movement, tone-quality, pitch, tonal memory, and rhythm. The literature on the psychology of reading reveals nothing quite comparable to this discovery.

9. The substrata-factor arrowheads indicating the lines of support from the outer to the innermost area portray in one direction only an adequate picture of the *generalized working-system.* That is, since the Substrata-Factor Theory hypothesizes a mutual-and-reciprocal cause and effect relationship, a truer representation would perhaps have presented the arrowheads as diamond-shaped to indicate the interfacilitating nature of the mutual-and-reciprocal support among the elements of the hierarchy. The reciprocal cause and effect interplay between and among variables, of course, need *not* be equal in both or every direction. More will be said of this in the discussion of "Basic Assumptions" in the appendix.

Chapter VII. A Comparative Substrata Analytic Study on Speed and Power of Reading for High School Boys vs. Girls

Introduction

The purpose of this section was to discover whether or not the 211 boys and the 189 girls in the total sample of 400 high school students would manifest different strengths and weaknesses on the cooperant abilities which underlie reading. A further purpose was to discover the degree to which each of these known-groups utilized a different set of subabilities in shearing off internal competition within its own group in the field of reading.

Table 11 gives the means and standard deviations for the boys and girls on all variables. The significance of the sex differences for these means are also indicated. Scrutiny of the table reveals that for the two criteria, Speed and Power of Reading, *the girls read significantly faster than the boys, but that there is no significant difference in their ability to read for power.* In the 54 independent variables, there are only 13 differences significant at the 1-percent level of confidence. The boys show their superiority in spatial and mechanical aptitude. In the linguistic area, the girls have an edge over the boys in phonetic association, word sense, and spelling. Likewise, the girls outshine the boys in the word embedded test—an instrument for assessing speed of visual verbal closure for word figures embedded in a random letter background. No significant differences appear in the areas of auding, elements of musical perception, and study habits. However, boys show a greater interest than girls in the outdoor, mechanical, computational, and science areas, but girls manifest greater interest in the artistic, social service, and clerical interest areas. No significant differences are evident in the mean scores of the two groups in any of the specific categories within the personal problems, musicality, and chronological age domains.[1]

Reference to figure 8 shows the profiles for each of the 2 known-groups when their raw score means have been transmuted into Z-scores derived from the raw score means and standard deviations of the total sample of 400 high school students; i.e.,

$$M_{z_b}\ \text{score}=10\left(\frac{M_b-M_T}{\partial_T}\right)+50$$

---

[1] The significance of the differences of the means were also tested on *2 samples of 200 each, drawn at random* from the total sample. Under these conditions no pairs of means were different at the 1-percent level.

Table 11.—Comparison of means and standard deviations for boys and girls on dependent and independent variables

Variables	Boys (N=211)		Girls (N=189)		Significance of DM*
	Mean	Standard deviation	Mean	Standard deviation	
Dependent:					
S. Speed of Reading	20. 06	7. 16	22. 13	8. 33	Y
P. Power of Reading	66. 89	16. 50	70. 48	16. 31	N
Independent:					
A. Mental abilities:					
1. Visual verbal meaning	29. 42	10. 01	31. 36	10. 64	N
2. Spatial relations	24. 05	11. 18	19. 69	12. 01	Y
3. Inductive reasoning	15. 07	6. 15	16. 60	7. 02	N
4. Word fluency	34. 04	11. 23	36. 67	12. 42	N
5. Speed of addition	18. 73	8. 94	17. 57	7. 26	N
6. Mechanical aptitude	35. 21	6. 82	28. 54	5. 10	Y
7. Verbal analogies	27. 76	7. 58	26. 24	7. 51	N
B. Linguistic abilities:					
8. Vocabulary in context	31. 61	6. 93	31. 91	7. 33	N
9. Vocabulary in isolation	31. 11	6. 55	31. 21	6. 49	N
10. Range of information	30. 26	6. 15	29. 15	6. 41	N
11. Phonetic association	48. 35	24. 33	57. 02	23. 64	Y
12. Word sense	32. 24	19. 15	38. 79	17. 84	Y
13. Homonymic meaning	30. 46	10. 81	32. 77	10. 03	N
14. Prefixes	8. 30	3. 63	8. 84	3. 46	N
15. Suffixes	7. 08	3. 58	7. 09	3. 16	N
16. Latin and Greek roots	14. 28	6. 00	14. 03	5. 57	N
17. Visual spelling recognition	22. 61	6. 40	24. 75	5. 96	Y
C. Verbal perception:					
18. Dot figure and ground	136. 02	25. 84	138. 28	29. 10	N
19. Cue-symbol closure	63. 67	13. 84	60. 83	13. 19	N
20. Word embedded	63. 58	20. 25	69. 41	19. 79	Y
21. Perception of reversals	77. 11	20. 13	79. 94	20. 46	N
D. Listening comprehension:					
22. Auding	31. 85	7. 87	31. 98	7. 80	N
E. Elements of musical ability:					
23. Tonal memory	21. 04	5. 39	21. 21	5. 98	N
24. Tone-quality	27. 74	5. 00	27. 39	5. 36	N
25. Tone-intensity	31. 78	8. 29	32. 17	7. 13	N
26. Tonal movement	35. 38	11. 19	36. 28	11. 22	N
27. Tone-time interval	23. 08	5. 03	22. 79	5. 11	N
28. Rhythm	23. 26	4. 70	23. 71	4. 31	N
29. Pitch	34. 98	7. 45	35. 42	7. 27	N
30. Musical taste	25. 72	6. 61	26. 22	6. 60	N

*At the 1 percent level of significance.

Table 11.—Comparison of means and standard deviations for boys and girls on dependent and independent variables—Continued

Variables	Boys (N=211)		Girls (N=189)		Significance of DM*
	Mean	Standard deviation	Mean	Standard deviation	
Independent—Continued					
F. Academic attitudes-habits:					
31. School adjustment and morale	50.47	9.44	51.03	10.14	N
32. Scholarly values	49.33	9.72	50.58	9.97	N
33. Mechanics of study	49.92	9.73	50.26	10.01	N
34. Effective study plan	50.20	11.10	51.13	10.43	N
G. Interest:					
35. Outdoor	43.61	14.44	34.74	14.40	Y
36. Mechanical	38.78	13.16	23.80	9.20	Y
37. Computational	27.18	8.32	20.64	8.47	Y
38. Science	44.73	13.54	33.02	13.45	Y
39. Persuasive	38.67	11.39	40.16	11.06	N
40. Artistic	26.73	9.95	31.81	10.45	Y
41. Literary	18.87	7.54	20.70	8.76	N
42. Musical	15.00	7.70	17.63	7.36	N
43. Social service	37.88	13.16	48.40	13.34	Y
44. Clerical	47.00	12.00	53.50	15.27	Y
H. Emotional-social problems:					
45. School problems	6.27	4.15	6.02	4.15	N
46. Postgraduation anxieties	11.81	8.43	10.82	7.58	N
47. Problems with self	6.29	6.41	7.53	6.59	N
48. Problems with others	6.88	6.22	7.63	6.64	N
49. Home-family problems	4.45	5.79	5.39	6.96	N
50. Boy-girl problems	4.07	4.87	4.51	5.00	N
51. Health problems	2.84	2.90	3.26	3.13	N
52. Conflict in values	4.60	5.90	5.38	6.38	N
I. Musicality:					
53. Musical appreciation	29.43	6.41	30.56	5.67	N
J. Age:					
54. Chronological age	197.19	15.04	196.92	13.63	N

*At the 1 percent level of significance.

where M_{z_b} score equals the standard score form of the boys' raw mean, M_b; and T represents the notation for the total group statistics. The first thing that strikes the eye is the symmetry of the two profiles, but a closer look reveals some deviations from the overall pattern in the mean Z-score differences for word embedded, mechanical, computational, science, artistic, and social service interest

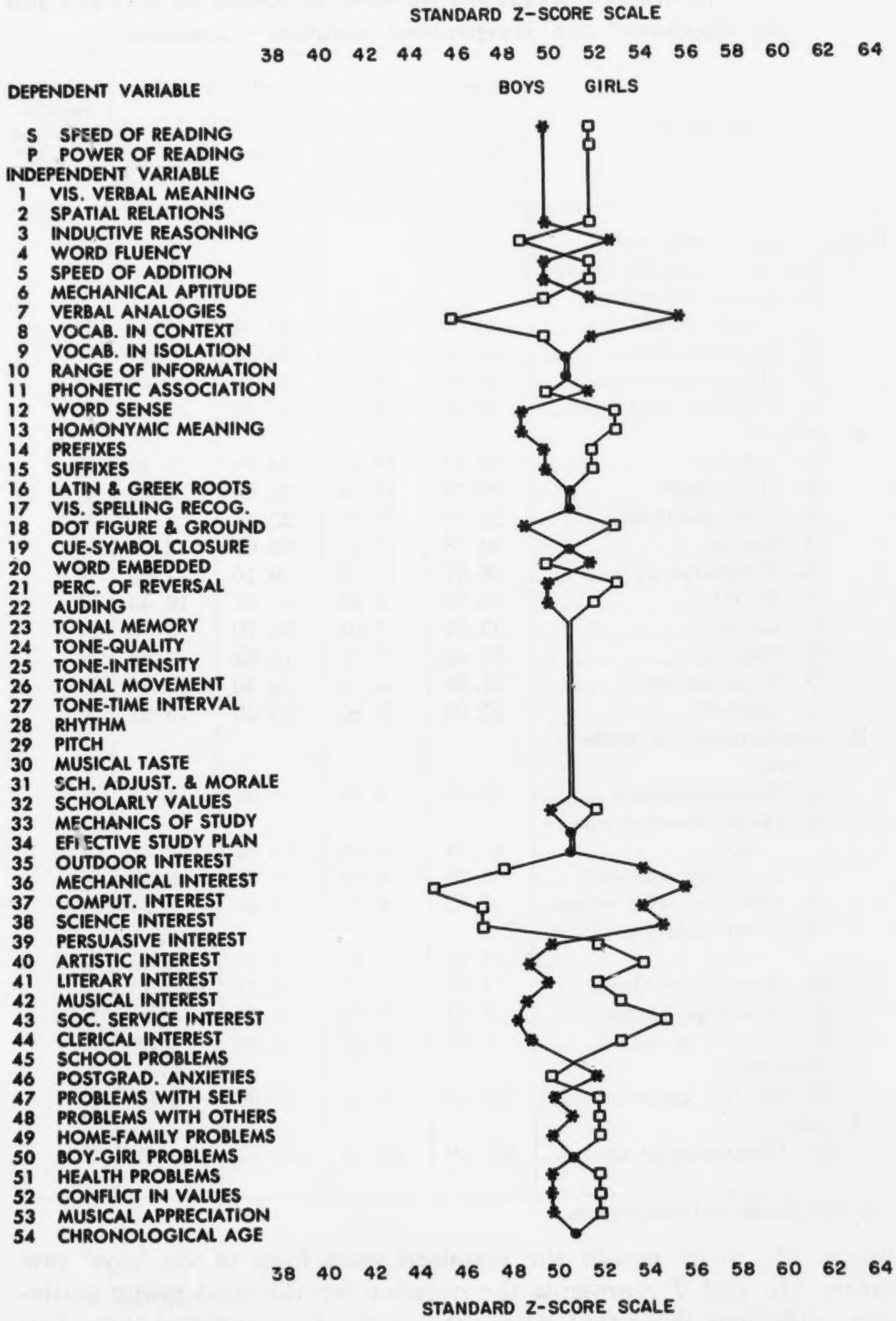


Figure 8.—Profile comparison of cooperant abilities, interests, and problems manifested by the 211 boys and 189 girls in total sample of 400.

areas. Also impressive is the fact that the two groups have identical mean Z-scores on auding and on the elements of musical ability.

Part 1. Comparative Substrata Analyses for Speed of Reading: Boys vs. Girls

Table 12 gives a comparison of the zero-order coefficients of correlation for each of the independent variables with Speed of Reading for the boys and the girls. Reference to the right-hand column indicates that, of the 54 independent variables compared, only 2, verbal analogies and computational interest, show a significant sex difference at the 1-percent level of confidence.[2]

Although it cannot be claimed that a large number of significant differences appear in the zero-order correlations for the two sexes, it is also obvious that we have not yet looked at the complete picture. Of the 1,485 possible pairs of intercorrelations, the significance of the difference of only the 54 more pertinent ones were tested. To extend 1-to-1 comparison to include all the possible pairs of *r*'s would miss the point. A thorough investigation of our major hypothesis (i.e., that boys and girls utilize different sets of subabilities in Speed of Reading) requires a substrata analysis of the *entire matrix* for each sex *in terms of the criterion,* Speed of Reading. This will be done.[3]

Boys vs. Girls at Level I: Speed

When the 2 matrices of 1,485 intercorrelations each for the boys and the girls were submitted to substrata analyses, it was discovered that (*a*) for boys, visual verbal meaning, auding, and spelling ability, and (*b*) for girls, visual verbal meaning, auding, and homonymic meaning were the only 3 variables, respectively, that made significant contributions directly to the variance of Speed of Reading at *Level I.* Table 13, sections *A* and *B*, gives the *r*'s, cumulative $\overline{R}$'s, combined and total percent contributions which these preferentially selected variables make to the variance of Speed of Reading at *Level I* for each sex.

Comparison of sections *A* and *B*, table 13, reveals that, qualitatively, visual verbal meaning and auding are substrata factors underlying Speed of Reading in both sexes. Reference to table 5, chapter VI, will show that these two factors were also fundamental to Speed of Reading at *Level I* for the Total Sample. However, in order to

---

[2] When a similar comparison was made for 2 subsamples of 200 students drawn at random, it was likewise found that only 2 variables correlated with Speed of Reading that were significantly different for the 2 sections. Therefore, we cannot attach much significance to the differences in zero-order correlations found between boys and girls.

[3] When this was done for the 2 subsamples of 200 students drawn at *random,* the two substrata-factor working-systems were virtually identical.

Table 12.—Comparison of zero-order coefficients of correlation of independent variables with Speed of Reading for boys and girls

Variable	Boys (N=211) *r*	Girls (N=189) *r*	Significance of difference 1%
Independent			
A. Mental abilities:			
1. Visual verbal meaning	0.64	0.66	N
2. Spatial relations	.25	.29	N
3. Inductive reasoning	.43	.57	N
4. Word fluency	.32	.28	N
5. Speed of addition	.17	.32	N
6. Mechanical aptitude	.22	.35	N
7. Verbal analogies	.37	.60	Y
B. Linguistic abilities:			
8. Vocabulary in context	.51	.65	N
9. Vocabulary in isolation	.50	.65	N
10. Range of information	.52	.62	N
11. Phonetic association	.41	.52	N
12. Word sense	.53	.62	N
13. Homonymic meaning	.53	.62	N
14. Prefixes	.43	.44	N
15. Suffixes	.40	.37	N
16. Latin and Greek roots	.47	.52	N
17. Visual spelling recognition	.46	.48	N
C. Verbal perception:			
18. Dot figure and ground	.28	.44	N
19. Cue-symbol closure	.24	.33	N
20. Word embedded	.39	.42	N
21. Perception of reversals	.26	.31	N
D. Listening comprehension:			
22. Auding	.55	.66	N
E. Elements of musical ability:			
23. Tonal memory	.22	.36	N
24. Tone-quality	.26	.18	N
25. Tone-intensity	.21	.31	N
26. Tonal movement	.19	.34	N
27. Tone-time interval	.08	.15	N
28. Rhythm	.25	.22	N
29. Pitch	.17	.39	N
30. Musical taste	.12	.22	N
F. Academic attitudes-habits:			
31. School adjustment and morale	.13	.30	N
32. Scholarly values	.04	.07	N
33. Mechanics of study	.05	−.03	N
34. Effective study plan	.06	.14	N

Table 12.—Comparison of zero-order coefficients of correlation of independent variables with Speed of Reading for boys and girls—Con.

Variable	Boys (N=211) *r*	Girls (N=189) *r*	Significance of difference 1%
Independent—Continued			
G. Interest:			
35. Outdoor	0.11	0.09	N
36. Mechanical	–.10	–.11	N
37. Computational	–.07	.32	Y
38. Science	.02	.08	N
39. Persuasive	.01	–.00	N
40. Artistic	–.10	.02	N
41. Literary	.20	.30	N
42. Musical	.10	–.07	N
43. Social service	–.03	–.03	N
44. Clerical	–.09	–.30	N
H. Emotional-social problems:			
45. School problems	–.15	–.24	N
46. Postgraduation anxieties	–.13	–.24	N
47. Problems with self	–.13	–.10	N
48. Problems with others	–.14	–.11	N
49. Home-family problems	–.09	–.02	N
50. Boy-girl problems	–.04	–.11	N
51. Health problems	.03	–.10	N
52. Conflict in values	–.07	.02	N
I. Musicality:			
53. Musical appreciation	.08	.23	N
J. Age:			
54. Chronological age	.02	–.19	N

shear off within-group competition in Speed of Reading, the boys appear to take special advantage of their individual differences in spelling ability, while the girls do the same for homonymic meaning. Quantitatively, table 13 indicates that, while visual verbal meaning is the most important factor contributing to *individual differences* in speed for boys, auding holds this distinction for girls.

Table 13.—Comparative analyses of boys vs. girls yielding accounted-for variance in Speed of Reading

Criterion Level 0	Substrata factor Level I	Zero-order r	Beta β	Cumulative $\overline{R}$	Contribution to variance accounted for (in percent)	
					Adjusted	Total
A. Boys (N=211)						
Speed of Reading	Visual verbal meaning	0. 64	0. 40	0. 642	25. 6	
	Auding	. 54	. 23	. 665	12. 4	
	Visual spelling recognition	. 46	. 18	. 682	8. 5	46. 5
B. Girls (N=189)						
Speed of Reading	Visual verbal meaning	0. 66	0. 28	0. 659	18. 6	
	Auding	. 66	. 35	. 729	22. 9	
	Homonymic meaning	. 62	. 24	. 749	14. 6	56. 1

Boys vs. Girls at Level II: Speed

The substrata analyses at *Level II* show that underlying the substrata factors for Speed of Reading are certain common elements used by both sexes and others specific to each. The following tabulation will clarify this general statement.

For Speed of Reading at Level 0

	Percent variance accounted for—	
	Boys	*Girls*
Underlying Visual Verbal Meaning Factor at *Level I* is found—		
At *Level II:*		
Vocabulary in context	19. 9	20. 3
Dot figure and ground	7. 3	7. 2
Homonymic meaning	18. 4	----
Tone-quality	5. 5	----
Word fluency	4. 0	----
Range of information	10. 7	----
Word sense	----	22. 4
Latin and Greek roots	----	9. 1
School adjustment and morale	----	4. 5
Underlying Auding Factor at *Level I* is found—		
At *Level II:*		
Range of information	27. 4	16. 1
Verbal analogies	17. 3	13. 7
Prefixes	10. 9	----
Vocabulary in context	----	34. 4
Latin and Greek roots	----	9. 8
Visual spelling recognition	----	−5. 0
Underlying Visual Spelling Recognition Factor at *Level I* is found—		
At *Level II:*		
Homonymic meaning	16. 5	----
Word embedded	10. 7	----
Phonetic association	14. 3	----
Perception of reversals	9. 5	----
Underlying Homonymic Meaning Factor at *Level I* is found—		
At *Level II:*		
Word sense	----	42. 8
Inductive reasoning	----	12. 2
Visual spelling recognition	----	13. 4

Because visual spelling recognition comes out as a *Level I* factor for the *boys*, it was precluded from appearing as an explanatory element at *Level II;* and the parallel situation holds for homonymic meaning for the *girls*. Further scrutiny of the results, however, reveals quite clearly that both homonymic meaning and spelling are important elements in Speed of Reading for both boys and girls. For the boys homonymic meaning appears to underlie visual verbal meaning and spelling, whereas for the girls, spelling underlies auding and homonymic meaning. Hence, while these elements (visual verbal meaning, auding, spelling, and homonymic meaning) appear to be especially important for Speed of Reading, the last two hold slightly different places in the hierarchy of the working-systems for boys and girls.

Boys vs. Girls at Level III: Speed

Analysis of the variables common to the two sexes at *Level II* reveals the following elements at *Level III:*

For *Speed of Reading at Level I*

	Percent variance accounted for—	
	Boys	*Girls*
Underlying Vocabulary in Context Factor at *Level II* is found—		
At *Level III*:		
Vocabulary in isolation	57.8	78.1
Word sense	12.3	-----
Underlying Range of Information Factor at *Level II* is found—		
At *Level III:*		
Vocabulary in isolation	64.0	51.1
Suffixes	7.0	-----
Tonal movement	----	4.6
Mechanical aptitude	----	5.2
Underlying Verbal Analogies Factor at *Level II* is found—		
At *Level III:*		
Vocabulary in isolation	44.1	35.3
Spatial relations	4.7	-----
Musical taste	4.3	-----
Health problems	1.2	-----
Cue-symbol closure	----	10.2
Tonal movement	----	6.1
Mechanical aptitude	----	6.6

The preferentially selected variables have been listed below in such a way as to indicate the Level at which each was precipitated for the boys and girls and whether or not it was common to the sexes.

Speed of Reading

Common and Specific Substrata Variables Regardless of Levels

	Level	
Common	*Boys*	*Girls*
Visual verbal meaning	I	I
Auding	I	I
Visual spelling recognition	I	II
Homonymic meaning	II	I
Vocabulary in context	II	II
Dot figure and ground	II	II
Range of information	II	II
Verbal analogies	II	II
Prefixes	II	III
Word embedded	II	III
Phonetic association	II	III
Perception of reversals	II	III
Word sense	III	II
Latin and Greek roots	III	II
Vocabulary in isolation	III	III

	Level	
Specific	*Boys*	*Girls*
Tone-quality	II	----
Word fluency	II	----
Boy-girl problems	III	----
School adjustment and morale	---	II
Inductive reasoning	---	II
Suffixes	III	----
Spatial relations	III	----
Musical taste	III	----
Health problems	III	----
Chronological age	III	----
Rhythm	III	----
Clerical interest	---	III
Artistic interest	---	III
Tonal movement	---	III
Mechanical aptitude	---	III
Cue-symbol closure	---	III

Of the 54 independent variables, 7 are both common to, and appear at, the same Levels in the hierarchy of boys and girls. Furthermore, there are eight other variables common to the hierarchies of the two sexes, but appearing at different Levels within the two working-systems. Finally, there appear to be large qualitative differences, for the two analyses precipitated nine variables specific to the boys' and seven specific to the girls' particular working-systems for Speed of Reading.

From the foregoing comparison it is evident that the major hypothesis (that known-groups use different sets of subabilities to read with speed) has been substantiated in the case of boys vs. girls in our sample. Of course, it is readily apparent that Speed of Reading is also a task which calls for the utilization of many fundamental abilities common to the two sexes, even though some of these may be used at parallel Levels and others at quite different Levels.

Summary for Speed of Reading: Boys vs. Girls

The flowcharts, figures 9 and 10, schematically present the overall results of the substrata analyses of the correlation matrices for 211 boys and 189 girls, respectively, for the Speed of Reading criterion. Each original matrix contained 1,485 correlations representing the interrelationships observed among the 55 variables.

A detailed comparison of the variables preferentially selected by the substrata analyses to account for Speed of Reading in the two sexes reveals that *the general hypothesis is indeed substantiated;* i.e., *that different known-groups mobilize different sets of subabilities within their separate working-systems in order to read for speed.* Reference to the flowcharts makes quite clear where the differences and similarities are.

Discussion. In comparing the working-systems of the boys and girls with that discovered for the total sample (see ch. VI), the reader should recall that *the multiple-correlation selection technique used in the substrata analysis always depends upon the manifest individual differences within the group being analyzed.* That is, even though a particular substrata variable might in fact be extremely important and actually used by a particular group in the working-system mobilized for Speed of Reading, that variable would not be selected if the individuals within the group all possessed or used the ability to the same degree. To put it another way, subabilities possessed and utilized more or less to the same degree as basic elements in the process of reading will not show up in the analysis, because, while fundamental to the process, they cannot contribute to individual differences in the criterion—since everyone uses them to the same extent. The important thing to keep in mind in evaluating and comparing the results from known-groups is that, in

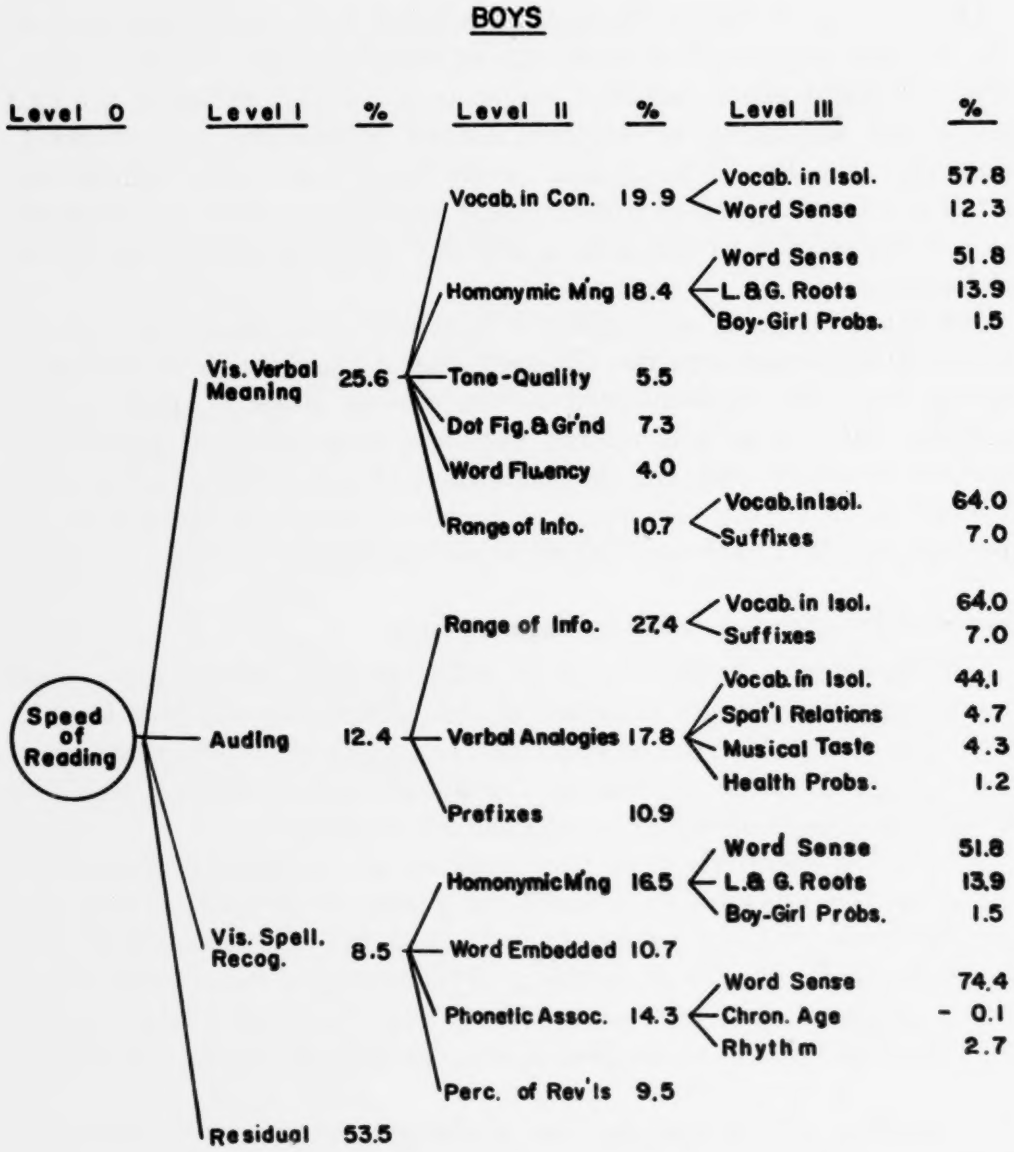

BOYS
Level 0
Level I
%
Level II
%
Level III
%
Vocab. in Con. 19.9
Vocab. in Isol. 57.8
Word Sense 12.3
Homonymic M'ng 18.4
Word Sense 51.8
L. & G. Roots 13.9
Boy-Girl Probs. 1.5
Vis. Verbal Meaning 25.6
Tone-Quality 5.5
Dot Fig. & Gr'nd 7.3
Word Fluency 4.0
Range of Info. 10.7
Vocab. in Isol. 64.0
Suffixes 7.0
Range of Info. 27.4
Vocab. in Isol. 64.0
Suffixes 7.0
Speed of Reading
Auding 12.4
Verbal Analogies 17.8
Vocab. in Isol. 44.1
Spat'l Relations 4.7
Musical Taste 4.3
Health Probs. 1.2
Prefixes 10.9
Homonymic M'ng 16.5
Word Sense 51.8
L. & G. Roots 13.9
Boy-Girl Probs. 1.5
Vis. Spell. Recog. 8.5
Word Embedded 10.7
Phonetic Assoc. 14.3
Word Sense 74.4
Chron. Age - 0.1
Rhythm 2.7
Perc. of Rev'ls 9.5
Residual 53.5

Figure 9.—Flowchart for Speed of Reading for 211 high school boys.

order to be selected, a variable in question must exert an influence in shearing off internal competition within the known-group under observation.

The most interesting difference in the two flowcharts, figures 9 and 10, is that spelling becomes one of the key primary factors accounting for success in Speed of Reading for boys, who are notoriously poor spellers, whereas homonymic meaning holds a parallel place for girls.

Analysis of these two tests indicates that homonymic meaning is really a very high-powered spelling test, calling for subtle audiovisual discriminations in spelling, their differential meanings, and the retention of such associations, so that homonymic meaning *as a spelling*

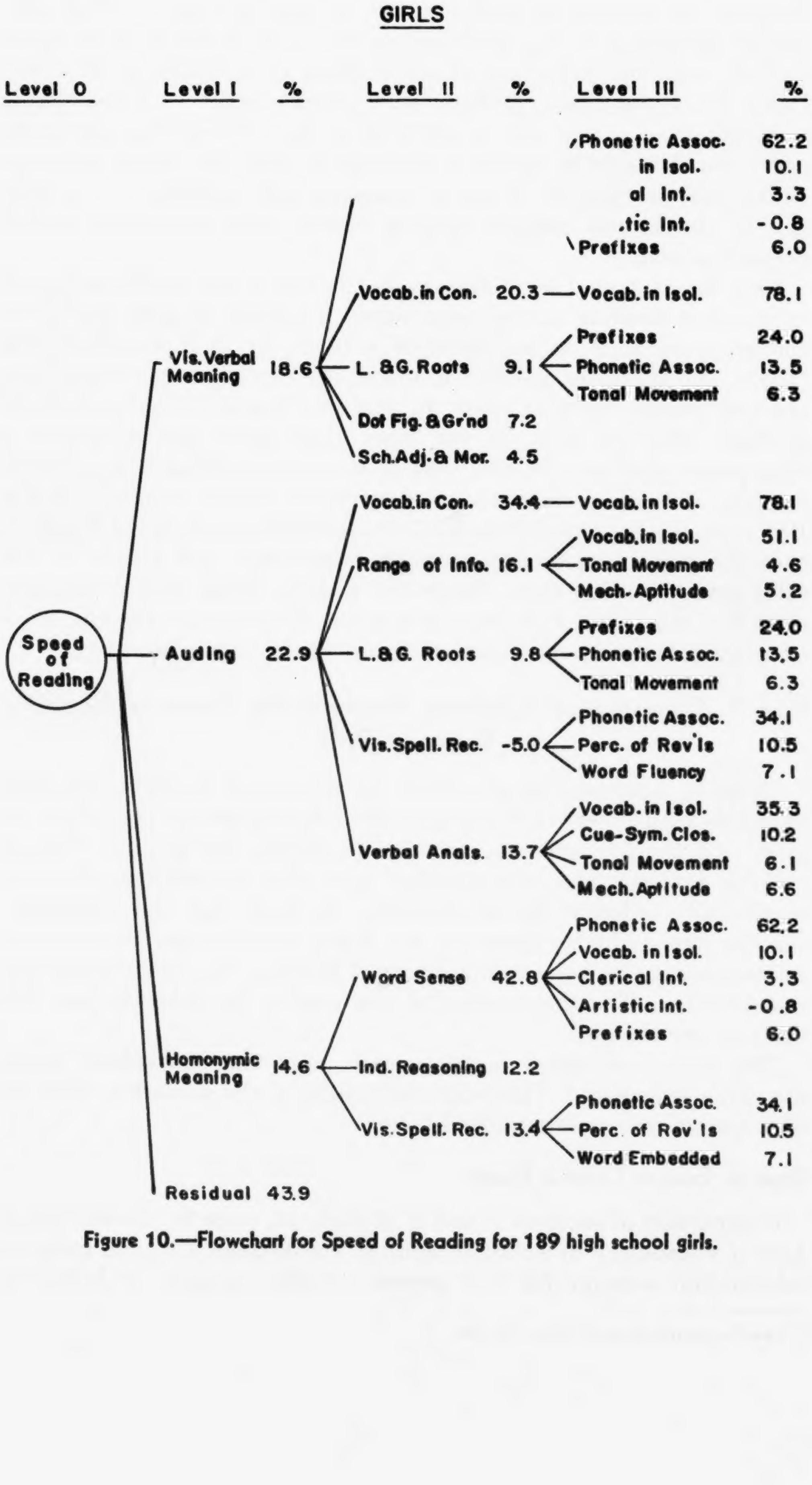

GIRLS
Level 0
Level I
%
Level II
%
Level III
%
Phonetic Assoc. 62.2
in Isol. 10.1
al Int. 3.3
.tic Int. -0.8
Prefixes 6.0
Vocab. in Con. 20.3
Vocab. in Isol. 78.1
Prefixes 24.0
Vis. Verbal Meaning 18.6
L. & G. Roots 9.1
Phonetic Assoc. 13.5
Tonal Movement 6.3
Dot Fig. & Gr'nd 7.2
Sch. Adj. & Mor. 4.5
Vocab. in Con. 34.4
Vocab. in Isol. 78.1
Vocab. in Isol. 51.1
Range of Info. 16.1
Tonal Movement 4.6
Mech. Aptitude 5.2
Prefixes 24.0
Speed of Reading
Auding 22.9
L. & G. Roots 9.8
Phonetic Assoc. 13.5
Tonal Movement 6.3
Phonetic Assoc. 34.1
Vis. Spell. Rec. -5.0
Perc. of Rev'ls 10.5
Word Fluency 7.1
Vocab. in Isol. 35.3
Cue-Sym. Clos. 10.2
Verbal Anals. 13.7
Tonal Movement 6.1
Mech. Aptitude 6.6
Phonetic Assoc. 62.2
Vocab. in Isol. 10.1
Word Sense 42.8
Clerical Int. 3.3
Artistic Int. -0.8
Prefixes 6.0
Homonymic Meaning 14.6
Ind. Reasoning 12.2
Phonetic Assoc. 34.1
Vis. Spell. Rec. 13.4
Perc of Rev'ls 10.5
Word Embedded 7.1
Residual 43.9

Figure 10.—Flowchart for Speed of Reading for 189 high school girls.

test goes far beyond the ordinary test of spelling ability. This particular conclusion is supported by the fact that underlying the homonymic meaning factor are visual spelling recognition, word sense, Latin and Greek roots, prefixes, and spatial relations. Generalizing from the two groups and total, it may be inferred that the more pervasive elements in Speed of Reading at the high school level are audiovisual recognition of word meanings, comprehension of human speech, simple and complex spelling ability, and audiovisual verbal perceptual acuity.

This demonstrated sex difference in the use of the substrata factors in Speed of Reading makes good sense, inasmuch as girls are better spellers than boys, as indicated in a study by Holmes and Finley (1957); and therefore, in order to utilize it for intragroup competition, the girls would have to resort to the most sophisticated aspects of spelling. For the boys, on the other hand, since spelling is one of their poorer abilities, the ones that do have it can utilize it as a special weapon, so to speak, to surmount competition within their own group. But when the boys meet the girls in competition for Speed of Reading, then the girls must be met on their own terms, and hence, for the total group, we find that, along with auding, visual verbal meaning, inductive reasoning, and literary interest, homonyms take the place of spelling as a primary substrata factor for Speed of Reading.

Part II. Comparative Substrata Analyses for Power of Reading: Boys vs. Girls

Table 14 compares the zero-order correlations of the 54 independent variables with Power of Reading in the 2 known-groups; i.e., boys vs. girls. Of the 54 variables, only 3—dot figure and ground, computational interest, and chronological age—yield correlations that are statistically different for the 2 sexes. In each case the correlation for the girls is higher than for the boys; and further, the greatest difference appears to be in the Power of Reading-vs.-chronological age relationship. The more powerful the reader, the older the boy, but the younger the girl!

The basic correlation matrices and supporting worksheet tables are given elsewhere.[4] However, the results of the substrata analyses of the matrices are summarized below.

Boys vs. Girls at Level I: Power

Comparison of sections A and B of table 15, page 95, shows that at *Level I* vocabulary in isolation, auding, verbal analogies, and range of information account for 71.7 percent of the variance in Power of

---

[4] See Cooperative Research Project No. 538.

Table 14.—Comparison of zero-order coefficients of correlation of independent variables with Power of Reading for boys and girls

Variable	Boys (N=211) *r*	Girls (N=189) *r*	Significance of difference 1 percent
Independent			
A. Mental abilities:			
1. Visual verbal meaning	0.65	0.69	N
2. Spatial relations	.23	.42	N
3. Inductive reasoning	.41	.61	N
4. Word fluency	.31	.31	N
5. Speed of addition	.24	.29	N
6. Mechanical aptitude	.38	.38	N
7. Verbal analogies	.72	.78	N
B. Linguistic abilities:			
8. Vocabulary in context	.76	.82	N
9. Vocabulary in isolation	.78	.79	N
10. Range of information	.77	.75	N
11. Phonetic association	.44	.53	N
12. Word sense	.56	.59	N
13. Homonymic meaning	.49	.58	N
14. Prefixes	.47	.45	N
15. Suffixes	.41	.26	N
16. Latin and Greek roots	.51	.46	N
17. Visual spelling recognition	.39	.45	N
C. Verbal perception:			
18. Dot figure and ground	.22	.48	Y
19. Cue-symbol closure	.30	.45	N
20. Word embedded	.32	.40	N
21. Perception of reversals	.16	.30	N
D. Listening comprehension:			
22. Auding	.73	.78	N
E. Elements of musical ability:			
23. Tonal memory	.28	.42	N
24. Tone-quality	.27	.30	N
25. Tone-intensity	.32	.42	N
26. Tonal movement	.27	.38	N
27. Tone-time interval	.06	.29	N
28. Rhythm	.22	.24	N
29. Pitch	.24	.35	N
30. Musical taste	.24	.23	N
F. Academic attitudes-habits:			
31. School adjustment and morale	.19	.28	N
32. Scholarly values	.04	.12	N
33. Mechanics of study	.08	.09	N
34. Effective study plan	.06	.19	N

Table 14.—Comparison of zero-order coefficients of correlation of independent variables with Power of Reading for boys and girls—Continued

Variable	Boys (N=211) *r*	Girls (N=189) *r*	Significance of difference 1 percent
G. Interest:			
35. Outdoor	0.00	0.09	N
36. Mechanical	−.01	−.08	N
37. Computational	−.03	−.29	Y
38. Science	.13	.09	N
39. Persuasive	.03	−.06	N
40. Artistic	−.09	.16	N
41. Literary	.15	.21	N
42. Musical	.03	−.03	N
43. Social service	−.15	−.02	N
44. Clerical	−.21	−.28	N
H. Emotional-social problems:			
45. School problems	−.20	−.24	N
46. Postgraduation anxieties	−.07	−.18	N
47. Problems with self	−.03	−.09	N
48. Problems with others	−.03	−.08	N
49. Home-family problems	.00	−.00	N
50. Boy-girl problems	.01	−.10	N
51. Health problems	.05	−.10	N
52. Conflict in values	.00	.06	N
I. Musicality:			
53. Musical appreciation	.17	.33	N
J. Age:			
54. Chronological age	.13	−.20	Y

Reading for boys, whereas vocabulary in context, verbal analogies, tone-intensity, visual verbal meaning, and auding together explain 77.9 percent of girls.

Vocabulary in one form or another, auding, and verbal analogies are common to both sexes at *Level I* as primary substrata factors underlying Power of Reading. Besides these common factors, range of information for boys and tone-intensity for girls are directly called upon by the respective groups to shear off in-group competition for tasks requiring ability to read with power.

Boys vs. Girls at Level II: Power

Table 16, sections *A* and *B*, presents the results of the substrata analyses of the systematically reduced correlation matrices for Power of Reading at *Level II* for boys and girls, respectively. Sections A and B of the table show that underlying the two fundamental common

Table 15.—Comparative analyses of boys vs. girls yielding accounted-for variance in Power of Reading

Criterion Level 0	Substrata factor Level I	Zero-order r	Beta β	Cumulative $\overline{R}$	Contribution to variance accounted for (in percent)	
					Adjusted	Total
	A. Boys (N=211)					
Power of Reading	Vocabulary in isolation	0.78	0.27	0.779	21.3	
	Auding	.72	.24	.824	17.6	
	Verbal analogies	.72	.22	.840	15.7	
	Range of information	.77	.22	.847	17.1	71.7
	B. Girls (N=189)					
Power of Reading	Vocabulary in context	0.81	0.34	0.813	27.5	
	Verbal analogies	.78	.25	.852	19.2	
	Tone-intensity	.42	.14	.866	5.6	
	Visual verbal meaning	.69	.16	.876	10.9	
	Auding	.78	.19	.882	14.7	77.9

Table 16.—Comparative analyses of boys vs. girls yielding accounted-for variance in Level I substrata factors underlying Power

Substrata factor Level I	Predictor Level II	Zero-order r	Beta β	Cumulative $\overline{R}$	Contribution to variance accounted for (in percent)	
					Adjusted	Total
A. Boys (N=211)						
From Power at Level 0 to—						
Vocabulary in isolation	Vocabulary in context	0. 82	0. 68	0. 822	55. 8	
	Visual verbal meaning	. 68	. 21	. 835	13. 9	69. 7
Auding	Vocabulary in context	. 67	. 42	. 665	27. 5	
	Visual verbal meaning	. 63	. 30	. 705	18. 7	
	Prefixes	. 52	. 23	. 719	11. 8	
	Visual spelling recognition	. 32	−. 16	. 728	−5. 0	53. 0
Verbal analogies	Vocabulary in context	. 72	. 69	. 717	49. 2	
	Health problems	−. 09	−. 13	. 727	1. 2	
	Tonal memory	. 30	. 17	. 736	4. 8	
	Musical interest	−. 04	−. 13	. 746	0. 5	55. 7
Range of information	Vocabulary in context	. 75	. 56	. 753	41. 6	
	Suffixes	. 47	. 18	. 777	8. 5	
	Visual verbal meaning	. 65	. 25	. 788	16. 1	
	Word embedded	. 22	−. 15	. 799	−3. 2	
	Science interest	. 18	. 11	. 806	2. 1	65. 1

B. Girls (N=189)

From Power at Level 0 to—

Vocabulary in context	Vocabulary in isolation	0. 88	0. 67	0. 884	59. 0	
	Range of information	. 75	. 20	. 892	15. 0	
	Computational interest	−. 39	−. 12	. 896	4. 7	
	Perception of reversals	. 25	. 09	. 900	2. 4	81. 1
Verbal analogies	Range of information	. 74	. 37	. 735	27. 1	
	Inductive reasoning	. 66	. 35	. 803	22. 9	
	Vocabulary in isolation	. 70	. 24	. 817	16. 8	66. 8
Visual verbal meaning	Word sense	. 70	. 32	. 700	22. 1	
	Vocabulary in isolation	. 68	. 31	. 761	20. 7	
	Dot figure and ground	. 48	. 16	. 779	7. 8	
	School adjustment and morale	. 36	. 13	. 789	4. 4	
	Latin and Greek roots	. 57	. 15	. 797	8. 5	63. 5
Auding	Vocabulary in isolation	. 75	. 42	. 750	31. 2	
	Range of information	. 73	. 32	. 788	23. 2	
	Inductive reasoning	. 55	. 17	. 800	9. 2	
	Outdoor interest	. 14	. 12	. 808	1. 7	65. 3
Tone-intensity	(Analysis completed.)					

substrata factors for Power of Reading (i.e., auding and verbal analogies), there are no subelements commonly utilized by both sexes. The following data, selected from table 16, are presented in order to facilitate the comparison:

For Power of Reading at *Level 0*

	Percent variance accounted for—	
Underlying Auding Factor at *Level I* is found—	*Boys*	*Girls*
At *Level II:*		
Vocabulary in context	27. 5	-----
Visual verbal meaning	18. 7	-----
Prefixes	11. 8	-----
Visual spelling recognition	−5. 0	-----
Vocabulary in isolation	-----	31. 2
Range of information	-----	23. 2
Inductive reasoning	-----	9. 2
Outdoor interest	-----	1. 7
Underlying Verbal Analogies Factor at *Level I* is found—		
At *Level II:*		
Vocabulary in context	49. 2	-----
Health problems	1. 2	-----
Tonal memory	4. 8	-----
Musical interest	. 5	-----
Range of information	-----	27. 1
Inductive reasoning	-----	22. 9
Vocabulary in isolation	-----	16. 8

The key to sex differences at *Level II* for the elements underlying the *same* factors at *Level I* is that boys draw more heavily at *Level I* on vocabulary in isolation and range of information to shear off in-group competition, whereas girls use vocabulary in context, visual verbal meaning, and tone-intensity. A sex comparison of the substructural elements at *Levels I* and *II* shows that, as previously discovered for the total sample (see table 8), vocabulary in context, auding, verbal analogies, vocabulary in isolation, visual verbal meaning, and tone-intensity are particularly important for Power of Reading, but that these elements are utilized differently by the two sexes. Range of information makes a direct contribution to the variance of Power of Reading for the boys and therefore is particularly important as a first-order factor for them. For the girls, however, range of information is more pervasive and exerts, from its position in *Level II*, an indirect influence on Power through the three primary factors, vocabulary in context, verbal analogies, and auding.

Boys vs. Girls at Level III: Power

The results of the respective substrata analyses for boys and girls at *Level III* are shown in the summary (figs. 11 and 12) along with those for *Levels I* and *II*.

By abstracting the common and specific elements in these Power working-systems for both boys and girls, a tabulation of likenesses and differences may be made. The abstracted list is presented below:

Power of Reading

Common and Specific Substrata Variables Regardless of Levels

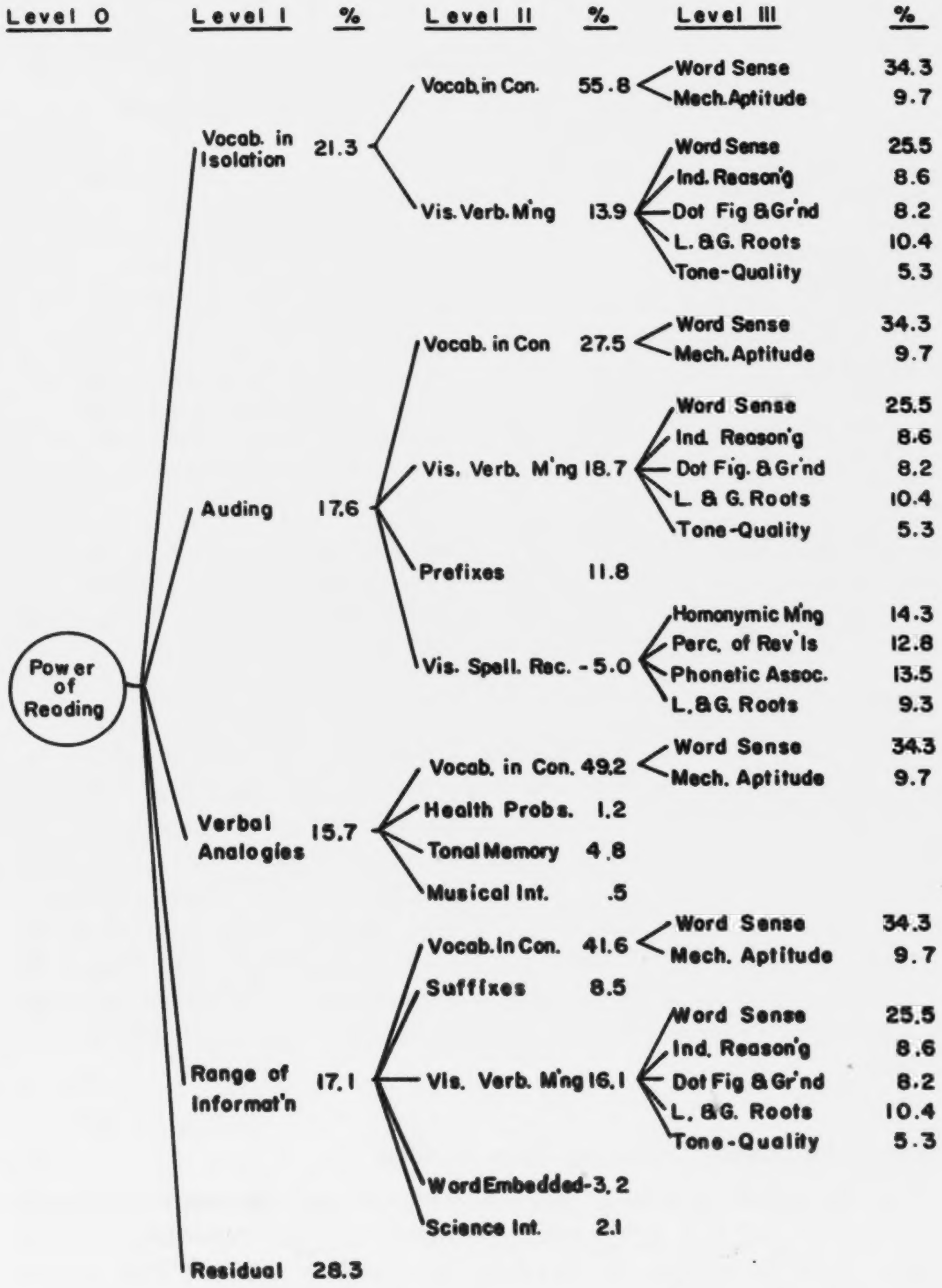
	Level	
Common	*Boys*	*Girls*
Vocabulary in isolation	I	II
Auding	I	I
Verbal analogies	I	I
Range of information	I	II
Vocabulary in context	II	I
Visual verbal meaning	II	I
Prefixes	II	III
Perception of reversals	III	II
Inductive reasoning	III	II
Dot figure and ground	III	II
Latin and Greek roots	III	II
Word sense	III	II
Mechanical aptitude	III	III
Homonymic meaning	III	III
Phonetic association	III	III

	Level	
Specific	*Boys*	*Girls*
Tone-intensity	---	I
Visual spelling recognition.	II	----
Health problems	II	----
Tonal memory	II	----
Musical interest	II	----
Suffixes	II	----
Word embedded	II	----
Science interest	II	----
Computational interest	---	II
School adjustment and morale.	---	II
Outdoor interest	---	II
Tone-quality	III	----
Clerical interest	---	III
Tone-time interval	---	III
Tonal movement	---	III
Chronological age	---	III

From the above it is obvious that within the organization of the respective working-systems for Power of Reading, the high school boys and girls of our sample utilize hierarchies which do indeed contain significant, qualitative, and quantitative substrata factor differences. This conclusion directly supports the major hypothesis of this study even more precisely than did the similar conclusion derived from comparing the analyses made on the two sexes for Speed of Reading. The reason for the greater precision is the fact that a comparison of the means indicated no significant difference in the ability of the two known-groups to read for power.

Summary for Power of Reading: Boys vs. Girls

The flowcharts, figures 11 and 12, respectively, represent schematic breakdowns for the preferential elements of the substrata factors which underlie Power of Reading in the two sexes. The charts succinctly summarize the findings for the two sexes and make a comparison by direct observation possible.



BOYS

Level 0
Level I
%
Level II
%
Level III
%
Power of Reading
Vocab. in Isolation 21.3
Vocab. in Con. 55.8
Word Sense 34.3
Mech. Aptitude 9.7
Vis. Verb. M'ng 13.9
Word Sense 25.5
Ind. Reason'g 8.6
Dot Fig & Gr'nd 8.2
L. & G. Roots 10.4
Tone-Quality 5.3
Auding 17.6
Vocab. in Con 27.5
Word Sense 34.3
Mech. Aptitude 9.7
Vis. Verb. M'ng 18.7
Word Sense 25.5
Ind. Reason'g 8.6
Dot Fig. & Gr'nd 8.2
L. & G. Roots 10.4
Tone-Quality 5.3
Prefixes 11.8
Vis. Spell. Rec. -5.0
Homonymic M'ng 14.3
Perc. of Rev'ls 12.8
Phonetic Assoc. 13.5
L. & G. Roots 9.3
Verbal Analogies 15.7
Vocab. in Con. 49.2
Word Sense 34.3
Mech. Aptitude 9.7
Health Probs. 1.2
Tonal Memory 4.8
Musical Int. .5
Range of Informat'n 17.1
Vocab. In Con. 41.6
Word Sense 34.3
Mech. Aptitude 9.7
Suffixes 8.5
Vis. Verb. M'ng 16.1
Word Sense 25.5
Ind. Reason'g 8.6
Dot Fig & Gr'nd 8.2
L. & G. Roots 10.4
Tone-Quality 5.3
Word Embedded -3.2
Science Int. 2.1
Residual 28.3

Figure 11.—Flowchart for Power of Reading for 211 high school boys.

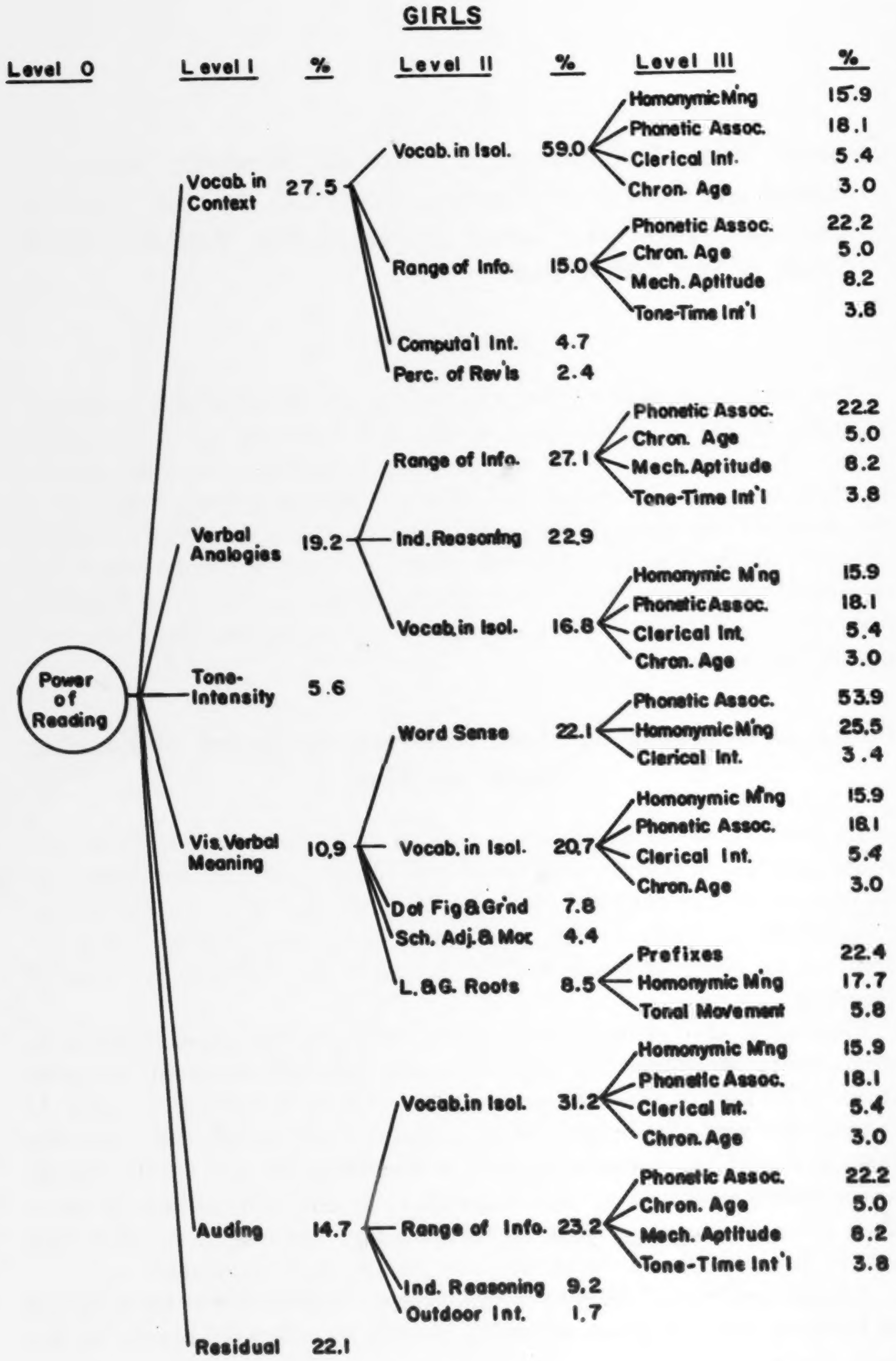

GIRLS
Level 0
Level I
%
Level II
%
Level III
%
Power of Reading
Vocab. in Context 27.5
Vocab. in Isol. 59.0
Homonymic M'ng 15.9
Phonetic Assoc. 18.1
Clerical Int. 5.4
Chron. Age 3.0
Range of Info. 15.0
Phonetic Assoc. 22.2
Chron. Age 5.0
Mech. Aptitude 8.2
Tone-Time Int'l 3.8
Computa'l Int. 4.7
Perc. of Rev'ls 2.4
Verbal Analogies 19.2
Range of Info. 27.1
Phonetic Assoc. 22.2
Chron. Age 5.0
Mech. Aptitude 8.2
Tone-Time Int'l 3.8
Ind. Reasoning 22.9
Vocab. in Isol. 16.8
Homonymic M'ng 15.9
Phonetic Assoc. 18.1
Clerical Int. 5.4
Chron. Age 3.0
Tone-Intensity 5.6
Vis. Verbal Meaning 10.9
Word Sense 22.1
Phonetic Assoc. 53.9
Homonymic M'ng 25.5
Clerical Int. 3.4
Vocab. in Isol. 20.7
Homonymic M'ng 15.9
Phonetic Assoc. 18.1
Clerical Int. 5.4
Chron. Age 3.0
Dot Fig & Gr'nd 7.8
Sch. Adj. & Moc 4.4
L. & G. Roots 8.5
Prefixes 22.4
Homonymic M'ng 17.7
Tonal Movement 5.8
Auding 14.7
Vocab. in Isol. 31.2
Homonymic M'ng 15.9
Phonetic Assoc. 18.1
Clerical Int. 5.4
Chron. Age 3.0
Range of Info. 23.2
Phonetic Assoc. 22.2
Chron. Age 5.0
Mech. Aptitude 8.2
Tone-Time Int'l 3.8
Ind. Reasoning 9.2
Outdoor Int. 1.7
Residual 22.1

Figure 12.—Flowchart for Power of Reading for 189 high school girls.

Chapter VIII. A Comparative Substrata Analytic Study on Speed and Power of Reading For High School Students Earning "High" vs. "Low" Scores on the Verbal Ability Scale of the PMA Test

Introduction

The purpose of this section was to discover whether or not the 108 verbally brightest in contrast to the 108 verbally dullest students drawn from our sample of 400 mobilized different working-systems in order to read with Speed and Power. Selecting these students on the basis of their visual verbal meaning scores[1] (i.e., the verbal abilities subscale of the Primary Mental Abilities Test) not only effectively separated the groups on the two criteria, Speed and Power of Reading, but separated them in all the audiovisual, cognitive, linguistic, and perceptual areas as well.

Part I. Comparative Substrata Analyses for Speed of Reading: Bright vs. Dull

At *Level I*, for the *bright* group, visual verbal meaning was the only substrata factor precipitated from the matrix; and it accounted for 20 percent of the variance of Speed of Reading. For the *dull* group, vocabulary in context and word sense were precipitated; they accounted for some 37 percent of what makes for variation in Speed of Reading.

Figures 13 and 14 illustrate some interesting differences in the substrata factors mobilized by the bright and dull for intragroup competition. The key to the differences in the elements utilized at *Level II* is that the verbally bright, while perhaps utilizing all the substrata factors found to underlie Speed of Reading for the total sample, nevertheless meet intragroup competition by calling most heavily upon their strongest asset—visual verbal meaning. It will be recalled that this is the variable on which the two groups were separated.

A large measure of the 80-percent variance unaccounted for in Speed of Reading for this group certainly resides, as indicated above, in the

---

[1] Visual verbal meaning was for the total group the only vocabulary variable preferentially selected at *Level I* for both the Speed and Power of Reading criteria.

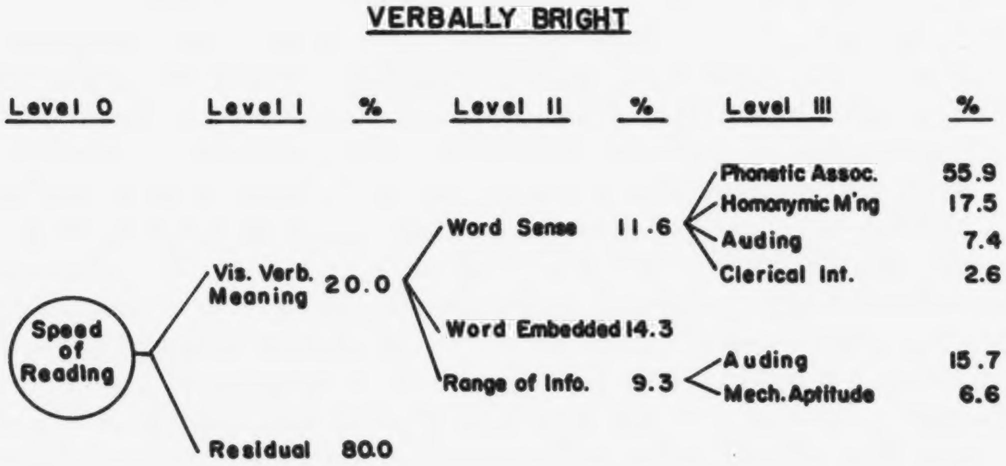

VERBALLY BRIGHT
Level 0
Level I
%
Level II
%
Level III
%
Speed of Reading
Vis. Verb. Meaning 20.0
Word Sense 11.6
Phonetic Assoc. 55.9
Homonymic M'ng 17.5
Auding 7.4
Clerical Int. 2.6
Word Embedded 14.3
Range of Info. 9.3
Auding 15.7
Mech. Aptitude 6.6
Residual 80.0

Figure 13.—Flowchart for Speed of Reading for 108 "bright" high school students.

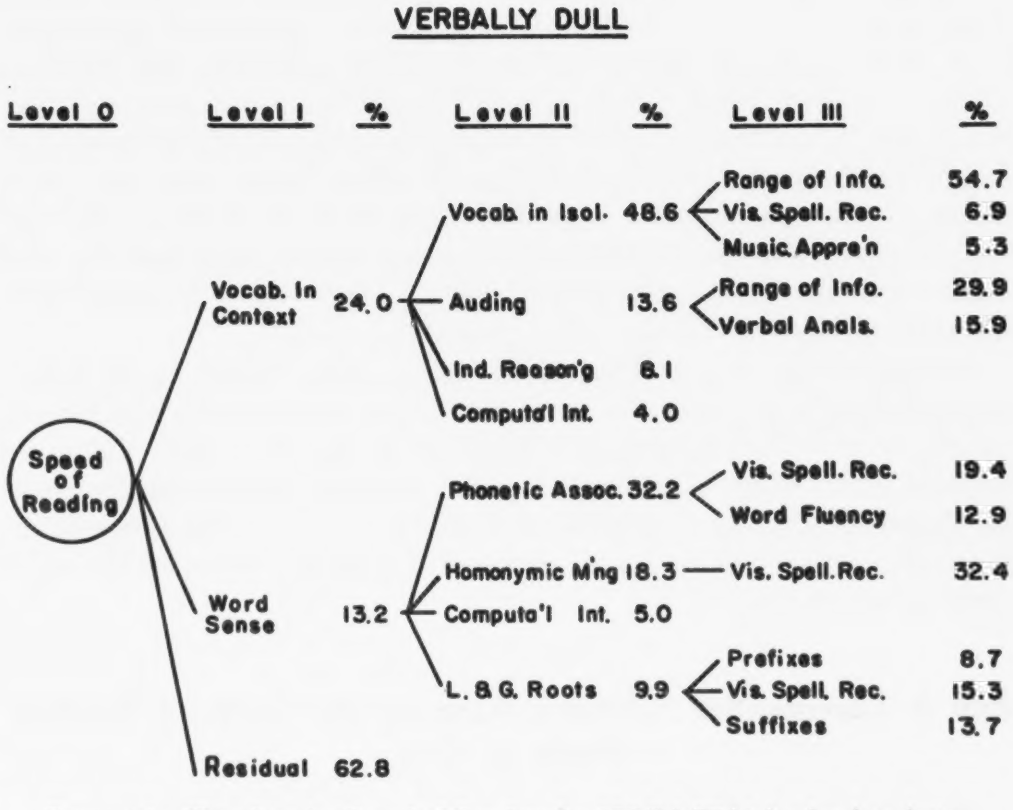

VERBALLY DULL
Level 0
Level I
%
Level II
%
Level III
%
Speed of Reading
Vocab. In Context 24.0
Vocab. in Isol. 48.6
Range of Info. 54.7
Vis. Spell. Rec. 6.9
Music. Appre'n 5.3
Auding 13.6
Range of Info. 29.9
Verbal Anals. 15.9
Ind. Reason'g 8.1
Computa'l Int. 4.0
Word Sense 13.2
Phonetic Assoc. 32.2
Vis. Spell. Rec. 19.4
Word Fluency 12.9
Homonymic M'ng 18.3
Vis. Spell. Rec. 32.4
Computa'l Int. 5.0
L. & G. Roots 9.9
Prefixes 8.7
Vis. Spell. Rec. 15.3
Suffixes 13.7
Residual 62.8

Figure 14.—Flowchart for Speed of Reading for 108 "dull" high school students.

host of audiovisual, intellectual, linguistic, and perceptual factors shown to be important in the total group. The fact that each of the members in the bright group has these abilities to a high degree, and that each of the members of the dull group tends to have them only to a slight degree, accounts for the low intercorrelations exhibited in the two matrices. Hence, these variables fail to make statistical contributions to the variance of Speed of Reading over and above that of visual verbal meaning for the bright, and vocabulary in context and word sense for the dull.

What makes the bright high school student a really superior reader is that he not only possesses and utilizes his great abilities in the audiovisual, cognitive, linguistic, and perceptual areas, but also has a well-developed perceptual ability for the rapid comprehension of the meaning of words. In contrast, the dull readers attack the Speed of Reading problem somewhat as if it were an assignment in comprehension. Lacking the requisite abilities, the dull readers compete within their own group by calling heavily upon vocabulary in context and word sense at *Level I*. These are buttressed at *Level II* by such analytic abilities as vocabulary in isolation, auding, inductive reasoning, phonetic association, homonymic meaning, and Latin and Greek roots; and at *Level III* by range of information, visual spelling recognition, musical appreciation, verbal analogies, prefixes, and suffixes. Obviously, for Speed of Reading, the dull readers are almost completely dependent upon the elements of word recognition. In contrast, the bright readers, at *Level II*, utilize word sense, word embedded, and range of information to a high degree; and at *Level III*, they call heavily upon phonetic association, homonymic meaning, auding, and mechanical aptitude to attain superiority. Note the basic importance of spelling for the verbally dull slow reader.

Evidently for the groups—total, boys, girls, bright, and dull—Speed of Reading is basically a psychoeducational process which cannot be divorced from linguistic abilities. It is also true that the more rapid a reader becomes, the more apt he is to have perfected the use of his linguistic abilities and to draw more heavily upon his range of information and perceptual and mechanical aptitudes to meet the competition of his peers.

Part II. Comparative Substrata Analyses for Power of Reading: Bright vs. Dull

Table 17 compares the zero-order correlations which the 54 independent variables make with Power of Reading in the 2 extreme known-groups; i.e., the verbally "bright" and "dull." The table shows that, of the 54 variables compared, 7 exhibit differences that are significant: vocabulary in context, vocabulary in isolation, range of information, auding, rhythm, musical taste, and musical appreciation. In each instance the correlation is larger for the "dull" group

Table 17.—Comparison of zero-order coefficients of correlation of independent variables with Power of Reading for bright vs. dull sample

Variable	Bright (N=108) *r*	Dull (N=108) *r*	Significance of difference 1 percent
Independent			
A. Mental abilities:			
1. Visual verbal meaning	0.44	0.41	N
2. Spatial relations	.16	.34	N
3. Inductive reasoning	.22	.42	N
4. Word fluency	.39	.39	N
5. Speed of addition	.13	.16	N
6. Mechanical aptitude	.15	.20	N
7. Verbal analogies	.50	.69	N
8. Vocabulary in context	.40	.77	Y
9. Vocabulary in isolation	.49	.78	Y
B. Linguistic abilities:			
10. Range of information	.46	.74	Y
11. Phonetic association	.29	.34	N
12. Word sense	.37	.46	N
13. Homonymic meaning	.24	.32	N
14. Prefixes	.40	.29	N
15. Suffixes	.21	.27	N
16. Latin and Greek roots	.28	.41	N
17. Visual spelling recognition	.22	.33	N
C. Verbal perception:			
18. Dot figure and ground	.02	.18	N
19. Cue-symbol closure	.17	.24	N
20. Word embedded	.20	.29	N
21. Perception of reversals	.05	.17	N
D. Listening comprehension:			
22. Auding	.42	.69	Y
E. Elements of musical ability:			
23. Tonal memory	.14	.41	N
24. Tone-quality	.02	.32	N
25. Tone-intensity	.15	.35	N
26. Tonal movement	.08	.29	N
27. Tone-time interval	.05	.12	N
28. Rhythm	−.10	.31	Y
29. Pitch	.05	.28	N
30. Musical taste	−.09	.28	Y
F. Academic attitudes-habits:			
31. School adjustment and morale	.17	.12	N
32. Scholarly values	.06	−.08	N
33. Mechanics of study	.03	−.01	N
34. Effective study plan	.13	.04	N

Table 17.—Comparison of zero-order coefficients of correlation of independent variables with Power of Reading for bright vs. dull sample—Con.

Variable	Bright (N=108) r	Dull (N=108) r	Significance of difference 1 percent
Independent—Continued			
G. Interest:			
35. Outdoor	−0. 06	−0. 16	N
36. Mechanical	−. 09	−. 11	N
37. Computational	−. 05	−. 14	N
38. Science	−. 04	. 06	N
39. Persuasive	−. 02	. 17	N
40. Artistic	. 05	. 08	N
41. Literary	. 25	. 03	N
42. Musical	−. 15	−. 02	N
43. Social service	. 05	. 13	N
44. Clerical	−. 10	−. 03	N
H. Emotional-social problems:			
45. School problems	−. 00	−. 26	N
46. Postgraduation anxieties	−. 03	−. 15	N
47. Problems with self	. 03	−. 06	N
48. Problems with others	−. 00	−. 02	N
49. Home-family problems	. 03	−. 08	N
50. Boy-girl problems	−. 04	−. 03	N
51. Health problems	. 08	−. 02	N
52. Conflict in values	. 16	−. 00	N
I. Musicality:			
53. Musical appreciation	−. 04	. 33	Y
J. Age:			
54. Chronological age	. 16	−. 01	N

than for the "bright" group. The seven highest *r*'s for the two groups are:

Correlations with Power of Reading

Bright	*r*	*Dull*	*r*
Verbal analogies	0. 50	Vocabulary in isolation	0. 78
Vocabulary in isolation	. 49	Vocabulary in context	. 77
Range of information	. 46	Range of information	. 74
Visual verbal meaning	. 44	Verbal analogies	. 69
Auding	. 42	Auding	. 69
Vocabulary in context	. 40	Word sense	. 46
Prefixes	. 40	Inductive reasoning	. 42

Figures 15 and 16 show the results of the substrata analyses of Power of Reading for the bright and dull groups. At *Level I*, verbal analogies and vocabulary in isolation are common to both groups. The bright group is especially adept in the utilization of visual verbal meaning, word fluency, and range of information in order to meet intragroup competition, whereas the dull group calls upon vocabulary in context and tonal movement over and above the abilities common to both groups at *Level I*.

Verbal analogies and vocabulary in one form or another are fundamental to power reading in both groups. However, only the bright make excessive use of visual verbal meaning, the test on which the known-groups were differentiated. *This illustrates our hypothesis that a special strength is capitalized upon to gain excellence*, not only in general, but within the subgroups. Nonetheless, the vocabulary factors are extremely important to both groups, and it would appear to depend upon the level of abstraction as to which form of vocabulary will be pressed into service for a particular group.

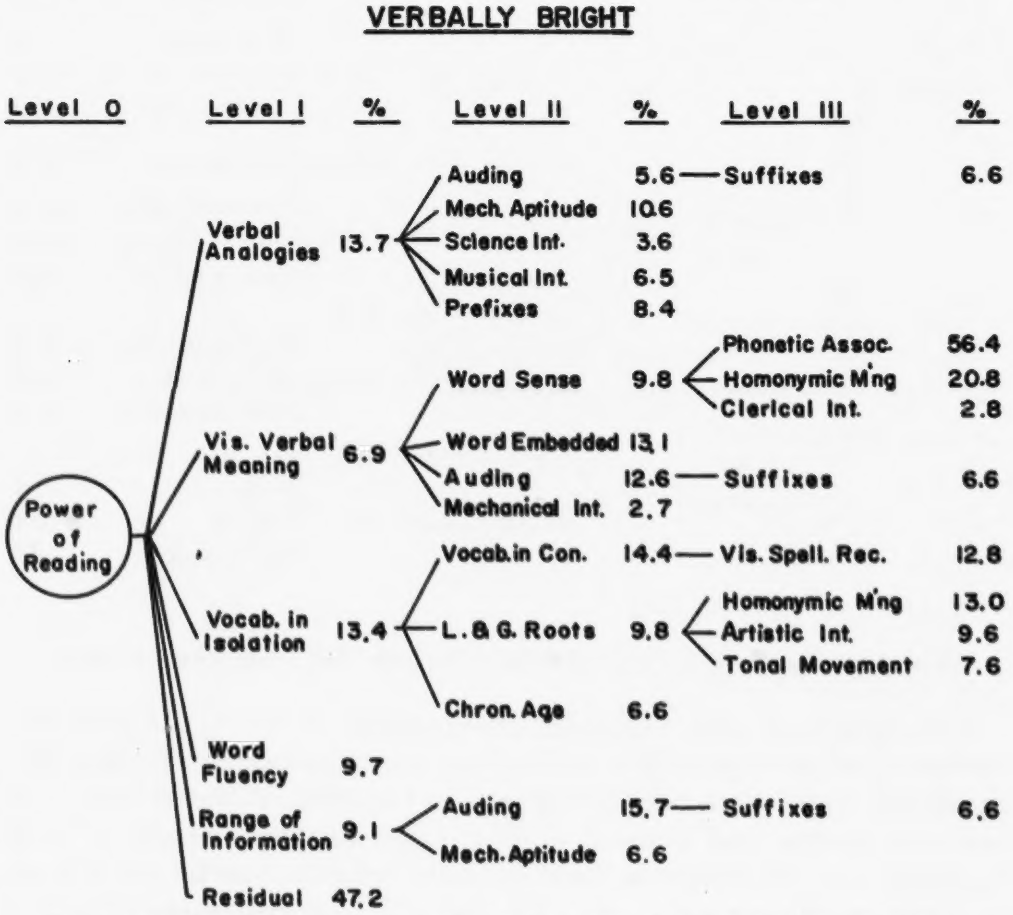

VERBALLY BRIGHT
Level 0
Level I
%
Level II
%
Level III
%
Power of Reading
Verbal Analogies 13.7
Auding 5.6
Suffixes 6.6
Mech. Aptitude 10.6
Science Int. 3.6
Musical Int. 6.5
Prefixes 8.4
Vis. Verbal Meaning 6.9
Word Sense 9.8
Phonetic Assoc. 56.4
Homonymic M'ng 20.8
Clerical Int. 2.8
Word Embedded 13.1
Auding 12.6
Suffixes 6.6
Mechanical Int. 2.7
Vocab. in Isolation 13.4
Vocab. in Con. 14.4
Vis. Spell. Rec. 12.8
L. & G. Roots 9.8
Homonymic M'ng 13.0
Artistic Int. 9.6
Tonal Movement 7.6
Chron. Age 6.6
Word Fluency 9.7
Range of Information 9.1
Auding 15.7
Suffixes 6.6
Mech. Aptitude 6.6
Residual 47.2

Figure 15.—Flowchart for Power of Reading for 108 "bright" high school students.

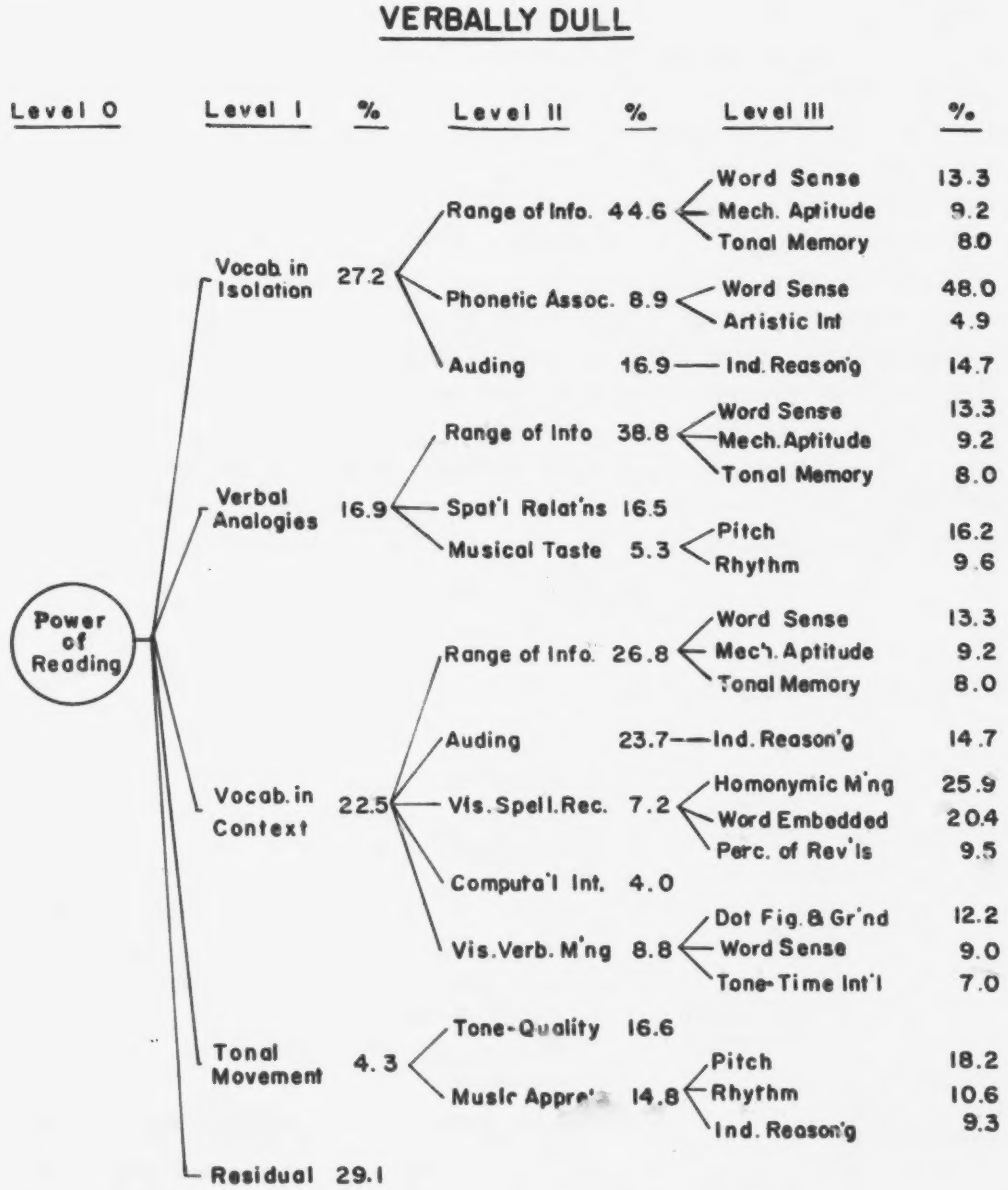

VERBALLY DULL
Level 0
Level I
%
Level II
%
Level III
%
Power of Reading
Vocab. in Isolation
27.2
Range of Info.
44.6
Word Sense
13.3
Mech. Aptitude
9.2
Tonal Memory
8.0
Phonetic Assoc.
8.9
Word Sense
48.0
Artistic Int
4.9
Auding
16.9
Ind. Reason'g
14.7
Verbal Analogies
16.9
Range of Info
38.8
Word Sense
13.3
Mech. Aptitude
9.2
Tonal Memory
8.0
Spat'l Relat'ns
16.5
Musical Taste
5.3
Pitch
16.2
Rhythm
9.6
Vocab. in Context
22.5
Range of Info.
26.8
Word Sense
13.3
Mech. Aptitude
9.2
Tonal Memory
8.0
Auding
23.7
Ind. Reason'g
14.7
Vis. Spell. Rec.
7.2
Homonymic M'ng
25.9
Word Embedded
20.4
Perc. of Rev'ls
9.5
Computa'l Int.
4.0
Vis. Verb. M'ng
8.8
Dot Fig. & Gr'nd
12.2
Word Sense
9.0
Tone-Time Int'l
7.0
Tonal Movement
4.3
Tone-Quality
16.6
Music Appre'
14.8
Pitch
18.2
Rhythm
10.6
Ind. Reason'g
9.3
Residual
29.1

Figure 16.—Flowchart for Power of Read[illegible] 8 "dull" high school students.

Comparison of the variables precipitated at *Levels II* and *III* further confirms our major and minor hypotheses. A striking dissimiliarity appears in the two groups in the area of the elements of auditory images and musical ability. Special use is made of tonal movement by the bright at *Level III* only, whereas special use is made of tonal movement at *Level I* by the dull. Furthermore, the dull group places a special dependence upon musical taste, tone-quality, and musical appreciation at *Level II* and pitch, tonal memory, rhythm, and tone-time interval at *Level III*. Likewise, while the visual perceptual factor of word embedded is used at *Level II* by the bright and at *Level III* by the dull, spatial relations and perception of reversals are important for the dull at *Levels II* and *III*. This would appear to mean that, *in Power of Reading, the dull group is especially dependent upon the basic elements of auditory and visual perception of linguistic symbols.* The audiovisual discrimination of these symbols is still a great problem for the dull, whereas for the bright, this aspect of reading has already been perfected and Power of Reading for them appears to be a rather high-level cognitive-linguistic process in which the symbolic manipulation of *ideas* is important. For Power, the bright also utilize a general knowledge and a precise vocabulary by which they easily extend this knowledge.

An overall evaluation suggests that, in terms of working-systems, the more sophisticated readers utilize linguistically meaningful subunits, such as Latin and Greek roots, prefixes, suffixes, etc., whereas the more naive readers utilize audiovisual perceptual cues, such as spatial relations, musical quality, tonal memory, rhythm, tone-time interval, etc., to derive the meaning of words, which in turn gives the meaning of the sentence. While both groups, to read with Power, must intellectually manipulate ideas presented in terms of audiovisual verbal analogies, because of the lack of linguistic knowledge, information, and vocabulary, the dull group has the further immediate task of deciphering the meaning of words through the use of context cues and word analysis; and to do this draws heavily upon perceptual discriminations in the auditory and visual areas.

Chapter IX. A Comparative Substrata Analytic Study on Speed of Reading For Known-Groups of Fast vs. Slow Readers

Introduction

The ability to read material ranging from easy to moderately difficult with speed and understanding is a valued asset in our society. At all levels in our schools, colleges, armed services, and industry, a great deal of time and money are spent in a persistent effort to improve the speed at which individuals are able to abstract meaning from the printed page. Moreover, with our advancing technology, instead of decreasing, the pressure is constantly increasing—man now must work hard at trying to keep apace of the machines he has invented to help him get his work done faster.[1]

Teachers have ingeniously devised and tried one method after another in the hope of finding one that would enable them to teach children to read faster. The educational psychologist, looking toward the same ultimate goal, must attack the problem from a different angle. It is clearly his function to devise experiments specifically designed to increase his understanding of the basic processes of reading rather than to strike out directly at formulating a "better" method of teaching reading on the basis of armchair logic. The question for him is one of understanding what the dimensions of reading are, how they work in the total or great "average" group, and in the specific known-groups in which he may be interested. When, by the accumulation of certain primary facts, he is able to construct a theory of reading, he is further obligated to draw the significant hypotheses which follow naturally from his theory. Each such hypothesis must then be tested by an experiment specifically designed for the task.

In accordance with the above tenets then, one hypothesis derived from the Substrata-Factor Theory is that fast and slow readers will manifest distinct and divergent scores on certain sets of cooperant abilities, interests, and personal-social problems. And for reading, each group will tend to mobilize those abilities which may be considered its strengths and minimize those which may be considered its weaknesses. These hypotheses have been tested on the 108 fastest and the 108 slowest readers.

---

[1] This was aptly illustrated by an ironic incident in the reading clinic on the University of California campus. A topflight executive had been so pleased with the improvement in his reading speed in a first course that he enrolled in an advanced class. Later he came to class obviously dejected, bemoaning the fact that "After a semester of hard work I became just able to read through a paperback novel as I flew across the continent—this was twice as many pages as I used to read before I took the course. Last week I took my first jet to New York, and so help me, it went so fast I was right back where I started—I only got halfway through my book!"

The Z-score profiles in figure 17 dramatically illustrate the raw score facts given in table 18. In terms of the total group, the fast readers have a mean Speed of Reading Z-score equivalent to 64, whereas the slow group earned a Z-score of only 40. In Power of Reading, the scores of the fast and slow groups were not as widely divergent as their speed scores. Nevertheless, it is plain that the fast readers are also, in general, the more powerful ones. However, the correlation is far from perfect ($r=0.594$).

Perhaps the most striking thing about the profiles is the extreme differences the two groups show in their auding ability, their knowledge of visual verbal meanings, word sense, and homonymic meanings. A strength of the fast group appears to be in tonal movement, whereas a relative weakness shows up in the area of mechanical aptitude. The high literary interest and low mechanical and computational interests of the fast group are also striking.

The latter observations are important in light of the oft-repeated statement that a child's *interest* is such and such and, therefore, one should naturally expect him to be a fast (or slow) reader. The slow reader does indeed show relative lack of literary interest, but stronger computational and clerical interests than either the fast or the average student.

Finally, it is somewhat surprising, in view of what some authorities have surmised about the relationship between reading and emotional-social maladjustment, that there are such small, and for the most part, insignificant differences in the means of the two groups on the scales of the SRA Youth Inventory.

Comparative Substrata Analyses for Speed of Reading: Fast vs. Slow

Careful scrutiny of figures 18 and 19 will show for Speed of Reading the comparative hierarchical breakdown of the substrata factors at *Levels I, II,* and *III* for the fast vs. slow readers.

At *Level I* (*a*) for the *fast* group, mechanical aptitude and visual spelling recognition account for 22 percent of the variance, and (*b*) for the *slow* group, vocabulary in context and chronological age account for 34 percent of the variance in Speed of Reading.

These findings are particularly interesting, since we know from the profile comparison that mechanical aptitude, relatively speaking, is one of the weakest abilities of the fast group and that the ages of the

Table 18.—Comparison of means and standard deviations for fast vs. slow readers on dependent and independent variables

Variable	Fast (N=108)		Slow (N=108)		Significance of DM*
	Mean	Standard deviation	Mean	Standard deviation	
Dependent					
S. Speed of Reading	30. 93	5. 40	12. 47	3. 39	Y
P. Power of Reading	78. 98	9. 70	54. 58	17. 34	Y
Independent					
A. Mental abilities:					
1. Visual verbal meaning	38. 84	8. 35	21. 18	7. 58	Y
2. Spatial relations	24. 85	11. 84	16. 96	11. 25	Y
3. Inductive reasoning	19. 89	5. 60	11. 03	5. 42	Y
4. Word fluency	39. 34	10. 62	30. 60	11. 90	Y
5. Speed of addition	20. 07	7. 36	15. 90	8. 53	Y
6. Mechanical aptitude	32. 16	6. 56	30. 27	6. 55	N
7. Verbal analogies	30. 67	5. 76	21. 65	8. 22	Y
B. Linguistic abilities:					
8. Vocabulary in context	35. 91	3. 51	25. 64	8. 44	Y
9. Vocabulary in isolation	34. 92	3. 40	25. 56	7. 74	Y
10. Range of information	33. 44	3. 62	24. 75	6. 90	Y
11. Phonetic association	66. 45	19. 86	35. 66	21. 42	Y
12. Word sense	48. 44	16. 32	21. 03	14. 10	Y
13. Homonymic meaning	38. 45	8. 90	23. 24	8. 53	Y
14. Prefixes	10. 41	3. 30	6. 56	2. 84	Y
15. Suffixes	8. 59	3. 32	5. 47	2. 86	Y
16. Latin and Greek roots	17. 44	5. 23	10. 43	4. 79	Y
17. Visual spelling recognition	26. 88	4. 66	19. 47	6. 40	Y
C. Verbal perception:					
18. Dot figure and ground	149. 32	22. 09	121. 99	30. 56	Y
19. Cue-symbol closure	66. 42	11. 64	57. 25	14. 19	Y
20. Word embedded	77. 44	16. 31	55. 59	20. 86	Y
21. Perception of reversals	86. 09	19. 56	70. 70	20. 88	Y
D. Listening comprehension:					
22. Auding	37. 32	6. 05	25. 64	7. 34	Y
E. Elements of musical ablity:					
23. Tonal memory	23. 23	5. 46	18. 90	5. 28	Y
24. Tone-quality	28. 65	4. 51	26. 24	5. 16	Y
25. Tone-intensity	33. 84	6. 46	29. 32	8. 44	Y
26. Tonal movement	40. 25	10. 14	32. 07	10. 50	Y
27. Tone-time interval	23. 63	3. 92	21. 79	4. 96	Y
28. Rhythm	24. 90	3. 84	22. 06	4. 67	Y
29. Pitch	37. 72	5. 60	32. 53	7. 20	Y
30. Musical taste	27. 93	6. 39	24. 96	6. 54	Y

---

*At the 1-percent level of significance.

Table 18.—Comparison of means and standard deviations for fast vs. slow readers on dependent and independent variables—Continued

Variable	Fast (N=108)		Slow (N=108)		Significance of DM*
	Mean	Standard deviation	Mean	Standard deviation	
Independent—Continued					
F. Academic attitudes-habits:					
31. School adjustment and morale	54. 07	9. 89	48. 35	8. 11	Y
32. Scholarly values	50. 90	9. 89	48. 54	10. 43	N
33. Mechanics of study	49. 82	9. 40	49. 06	10. 28	N
34. Effective study plan	52. 01	11. 18	50. 18	10. 65	N
G. Interest:					
35. Outdoor	38. 63	15. 52	39. 74	14. 61	N
36. Mechanical	27. 24	12. 49	33. 17	12. 95	Y
37. Computational	20. 07	9. 13	26. 34	6. 79	Y
38. Science	37. 90	15. 29	39. 16	13. 72	N
39. Persuasive	40. 16	12. 56	39. 49	9. 60	N
40. Artistic	30. 01	9. 85	28. 18	10. 31	N
41. Literary	23. 18	8. 60	18. 13	6. 35	Y
42. Musical	17. 29	7. 54	16. 47	8. 10	N
43. Social service	43. 28	15. 06	43. 61	12. 01	N
44. Clerical	47. 23	13. 11	53. 61	14. 00	Y
H. Emotional-social problems:					
45. School problems	5. 27	3. 89	7. 21	4. 02	Y
46. Postgraduation anxieties	9. 78	7. 13	13. 12	8. 50	Y
47. Problems with self	6. 18	6. 16	7. 86	7. 02	N
48. Problems with others	6. 39	5. 53	8. 08	7. 03	N
49. Home-family problems	5. 32	7. 24	5. 01	6. 32	N
50. Boy-girl problems	3. 75	4. 35	4. 49	5. 42	N
51. Health problems	2. 93	2. 99	3. 35	3. 07	N
52. Conflict in values	5. 32	6. 54	5. 23	6. 15	N
I. Musicality:					
53. Musical appreciation	31. 19	5. 23	28. 71	6. 50	Y
J. Age:					
54. Chronological age	196. 95	11. 77	198. 71	17. 37	N

*At the 1-percent level of significance.

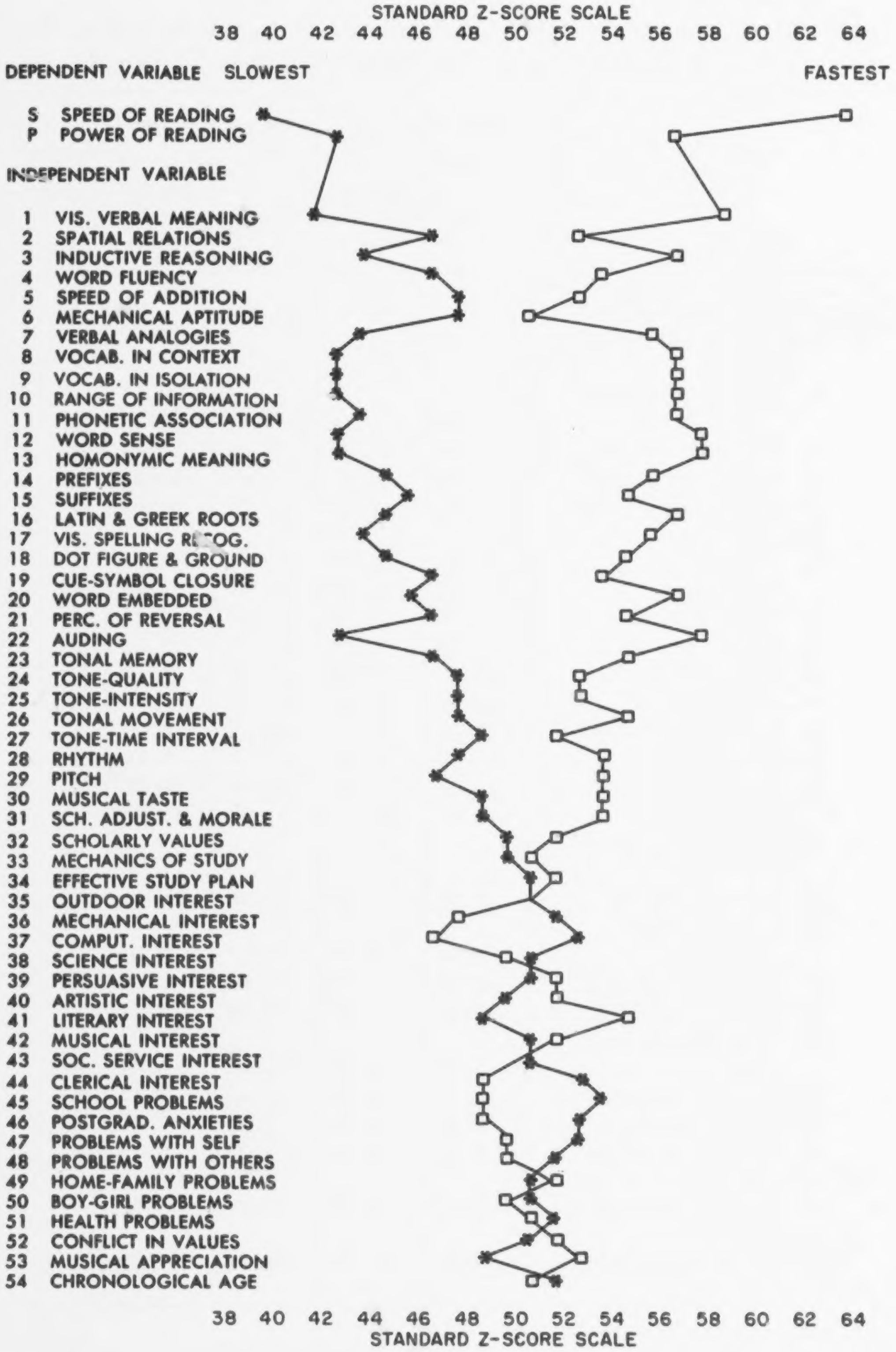


Figure 17.—Profile comparison of cooperant abilities, interests, and problems manifested by the 108 fastest and 108 slowest readers in the total sample of 400.

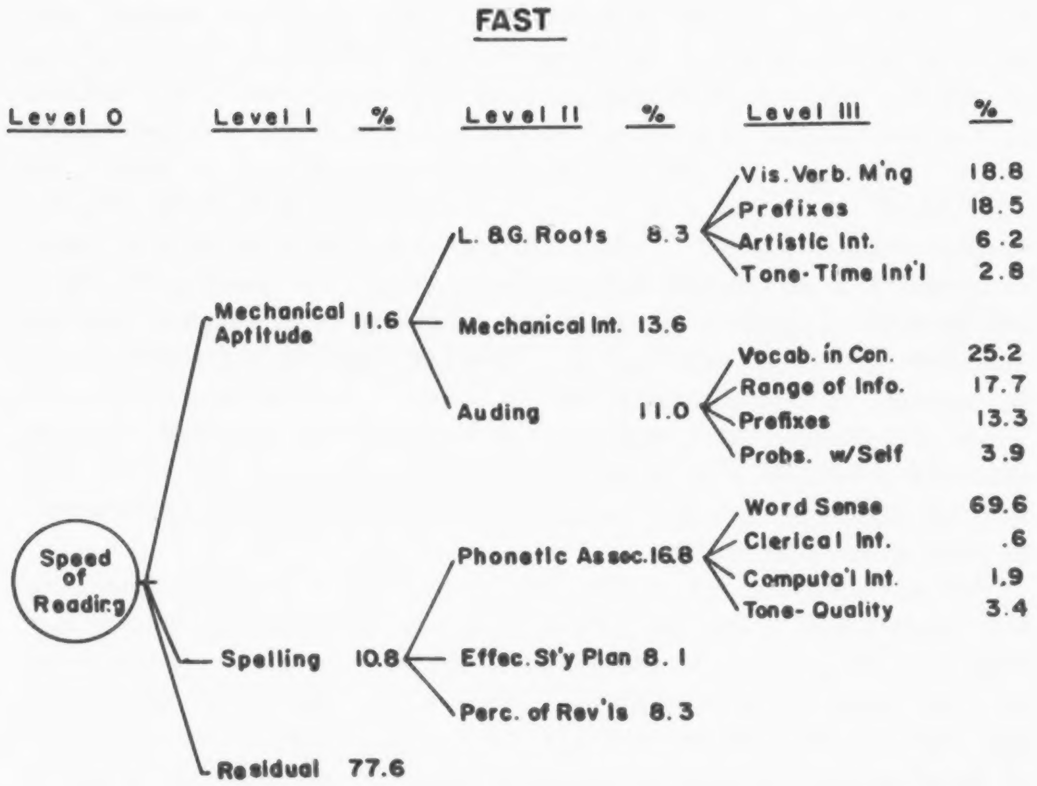

FAST
Level 0
Level I
%
Level II
%
Level III
%
Speed of Reading
Mechanical Aptitude 11.6
L. & G. Roots 8.3
Vis. Verb. M'ng 18.8
Prefixes 18.5
Artistic Int. 6.2
Tone-Time Int'l 2.8
Mechanical Int. 13.6
Auding 11.0
Vocab. in Con. 25.2
Range of Info. 17.7
Prefixes 13.3
Probs. w/Self 3.9
Spelling 10.8
Phonetic Assoc. 16.8
Word Sense 69.6
Clerical Int. .6
Computa'l Int. 1.9
Tone-Quality 3.4
Effec. St'y Plan 8.1
Perc. of Rev'ls 8.3
Residual 77.6

Figure 18.—Flowchart for Speed of Reading for 108 "fastest" high school students.

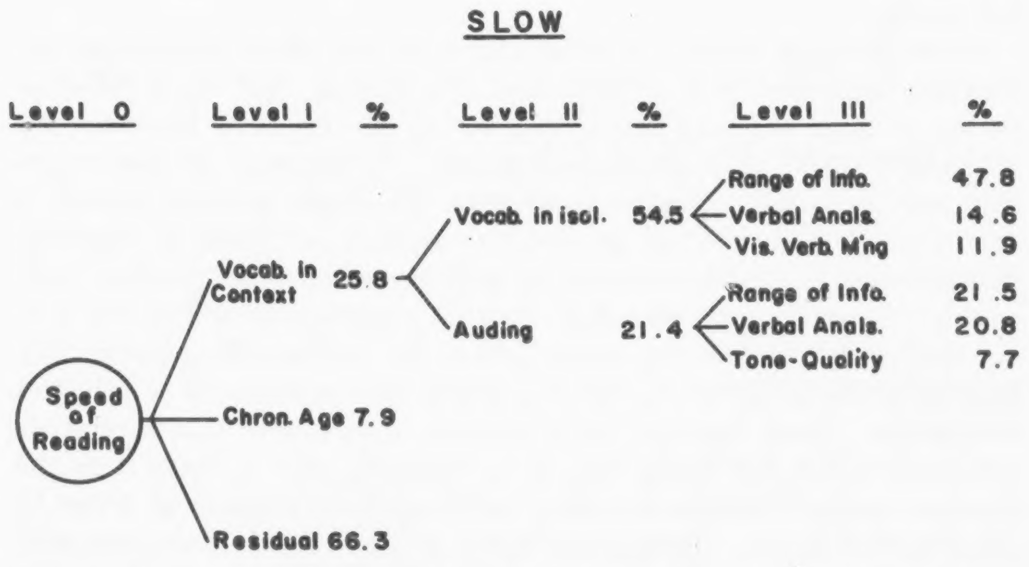

SLOW
Level 0
Level I
%
Level II
%
Level III
%
Speed of Reading
Vocab. in Context 25.8
Vocab. in isol. 54.5
Range of Info. 47.8
Verbal Anals. 14.6
Vis. Verb. M'ng 11.9
Auding 21.4
Range of Info. 21.5
Verbal Anals. 20.8
Tone-Quality 7.7
Chron. Age 7.9
Residual 66.3

Figure 19.—Flowchart for Speed of Reading for 108 "slowest" high school students.

two groups are almost identical. Clearly, the fast readers rely heavily at the primary level upon their individual differences in mechanical aptitude and spelling over and above their high abilities in the rest of the audiovisual, cognitive, linguistic, and perceptual areas. Likewise, the slow readers place a heavy load at *Level I* on vocabulary in context and thus tend to read for speed as the average student reads for power. Although age in the total group is of slight importance in accounting for success or failure in Speed of Reading, and in spite of the lack of significant difference in the ages of the fast and slow readers, it is evident that Speed of Reading in the slow group is inversely and significantly related to age. In the slow group, the faster the reader, the younger he is likely to be; one may surmise that this is because the children who do not read well in school and who are otherwise low in academic achievement tend to be retarded in their grade placement.

Perhaps the most interesting finding at *Level I* is that exceedingly fast readers call upon mechanical aptitude, in order to excel within their own group, even though mechanical aptitude, relatively speaking, is one of their weakest abilities. Here we see that what appears at first sight to be quite improbable (i.e., a relationship between Speed of Reading and mechanical aptitude)—and indeed it did not occur in the total sample—has nevertheless shown itself clearly in a more restricted group, in this case the fast readers. As a matter of fact, mechanical aptitude was the most valid predictor of Speed for the fast group.

These findings demand a modification of the minor hypothesis, as was also indicated in the bright and dull groups, but for a different reason. *There we found that a basic core of abilities must be utilized by all individuals if they are to read at all. Furthermore, it was shown that over and above these basic abilities, the bright students tended to capitalize on their strength in order to succeed in Speed of Reading. Now we see that the fast group is capitalizing on one of its relative weaknesses.* So at this point we discover that a particular ability which is not ordinarily used to any great extent by students in general may become a crucial factor in the intragroup competition of a selected subsample. Even though this particular ability is in fact a relative weakness within the fast group, the individuals who do have it to the greatest degree mobilize it within their working-systems in order to outstrip their peers. In a group that is highly verbal, those who *also* possess mechanical ability have a slight edge on those who do not—as far as speed of reading is concerned.

Chapter X. A Comparative Substrata Analytic Study on Power of Reading For Powerful vs. Nonpowerful Readers

Introduction

In this chapter the powerful and nonpowerful readers will be compared (*a*) by delineation of their cooperant strengths and weaknesses, and (*b*) by analysis of the degree to which each utilizes a different set of subabilities to excel in reading for power within his particular known-group.

How does "power" differ from "comprehension" in the field of reading? Comprehension refers to the ability to understand what is read. Power in reading carries with it the additional ability to use the information gained from the material read to solve problems or answer questions. *Comprehension denotes only a knowledge of, but power implies a working knowledge and use of, information and concepts derived from reading.*[1] Likewise, power in reading implies the creative ability of the reader to manipulate mentally what he has read in order to integrate it with what he already knows and thus gain insight into new relations that were not given to him in the reading per se. That is, the most powerful reader uses reading as an effective tool for his creative thinking.

Proceeding up the academic scale grade by grade, one finds that at each level the meaning of the printed page becomes increasingly difficult for students to comprehend. This, of course, is due to a variety of factors: the increasing complexity of the sentence structure, the style of writing, the vocabulary, and the greater depth of ideas and concepts used. Concomitantly, there is an increasing demand for the use of reason by the student in interpreting and applying what has been read in order to answer questions and solve problems which go beyond the information given. He cannot resolve such problems simply by a mechanical application of the facts and concepts as presented. Power reading, therefore, implies a contribution on the part of the reader! And the demand increases as he progresses in his school career. This phenomenon is consistent with the "gradient shift" hypothesis of the Substrata-Factor Theory.

---

[1] When I ask my students if they have understood how I derived a formula on the blackboard, they nod their heads. But many of them are unable either to derive it for themselves or even to use it properly until they have worked with it much longer. On first exposure, they obtain knowledge about it, but no *working* knowledge of it.

The essential elements in the educative process are the ideas stored in books—profound and trivial, good and bad, classical and new; but the heart of the educative process is the *power of the mind to read, understand, interpret, reason with, and use such concepts.* Speed of Reading is in keeping with the times; nevertheless, the crucial ideas in life, the understanding of those great concepts which have taken thousands of years to evolve, need not—indeed cannot—be fully grasped as one's speed of reading approaches its limit. Literature of great esthetic quality or of profound philosophic or intellectual import must be read slowly and reflectively if it is to be properly understood and appreciated. Otherwise, one has not really "read" it at all, but merely flipped the pages in record time. The secret of good reading lies in the ability to know when and how to change one's speed; this calls for a flexible attitude and a corresponding versatility in the ability to execute a change in pace.

While it may in no way be claimed that the passages in the criterion test of Power reading used in this study contain great ideas for the reader to wrestle with, it is claimed that the very best passages and questions do require from the student at the high school level a type of activity which closely approximates the processes required to handle great ideas. At the very least, the questions and problems are almost identical with what is required of the student in reading an assignment and answering questions at the end of a chapter. Power of Reading, then, is that aspect of reading which emphasizes reading as reasoning. Since it is claimed that high scorers on the criterion test of Power mobilize a different set of substrata factors than do low scorers, the profile and substrata analyses which follow are designed to test the validity of this hypothesis.

Cooperant Abilities of Powerful vs. Nonpowerful Readers

Figure 20 presents the profile comparison of the cooperant abilities, interests, and problems manifested by the 108 most powerful and the 108 least powerful readers in the total sample of 400 high school students. The general tendency for the nonpowerful to show concomitant deficiencies in verbally intellectual and linguistic areas is dramatically apparent.

In contrast to the low scores of the nonpowerful group noted above, the most powerful readers demonstrate definite assets in these same abilities. Most remarkable in their profile are the extremely high scores in visual verbal meaning, verbal analogies, auding, vocabulary in context and isolation, range of information, phonetic association, word sense, homonymic meaning, and Latin and Greek roots. Table 19 presents the respective means and standard deviations, and indicates the significance of the differences where applicable.

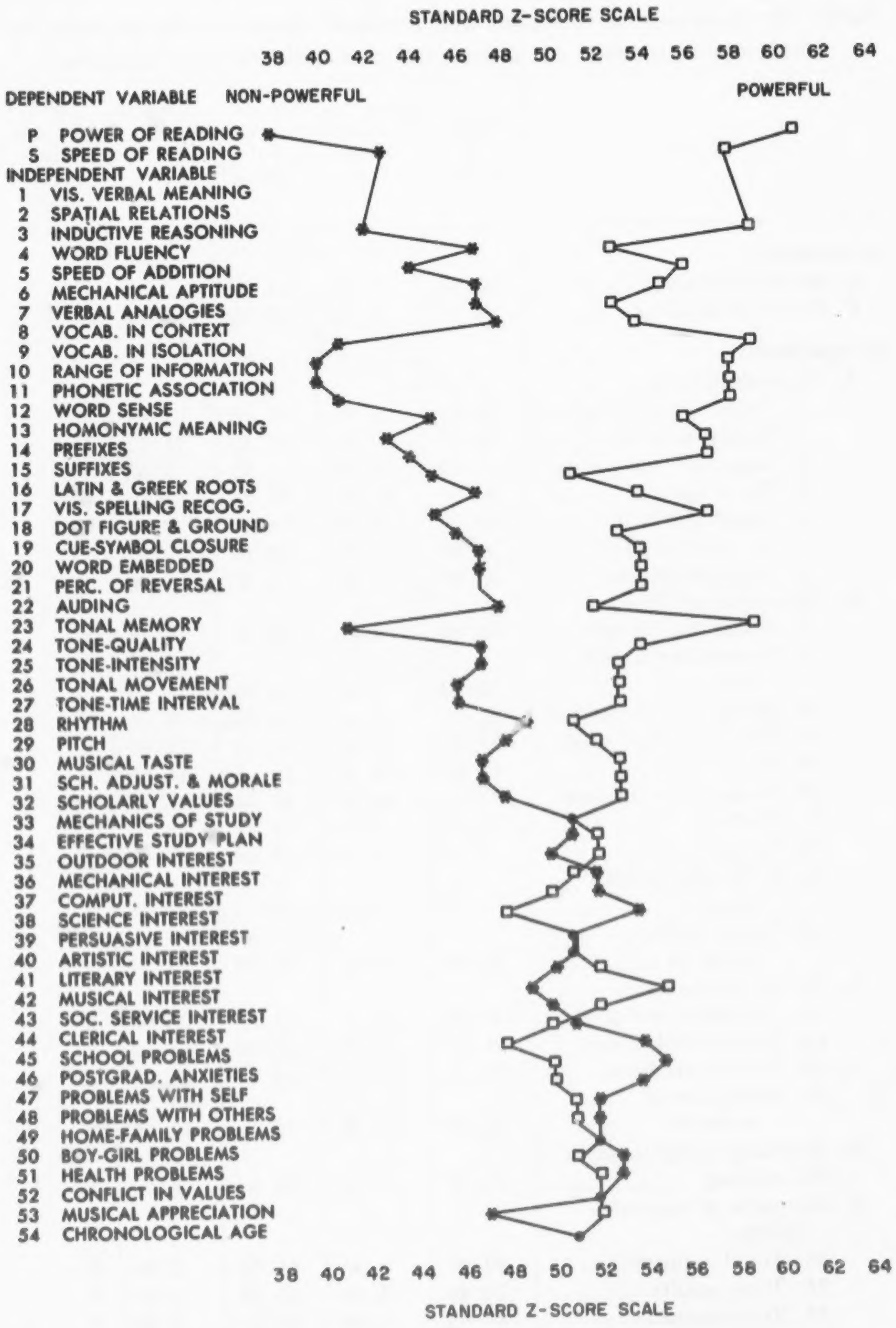


Figure 20.—Profile comparison of cooperant abilities, interests, and problems manifested by the 108 most powerful and 108 least powerful readers in total sample of 400.

Table 19.—Comparison of means and standard deviations for powerful vs. nonpowerful readers on dependent and independent variables

Variable	Powerful mean	(N=108) Standard deviation	Nonpowerful mean	(N=108) Standard deviation	Significance of difference (1%)
Dependent:					
S. Speed of Reading	26.54	7.94	15.06	5.30	Y
P. Power of Reading	85.35	3.32	45.87	11.12	Y
Independent:					
A. Mental abilities:					
1. Visual verbal meaning	38.18	8.56	21.10	7.68	Y
2. Spatial relations	24.70	10.53	17.45	11.55	Y
3. Inductive reasoning	18.89	6.25	11.36	5.58	Y
4. Word fluency	39.44	11.34	30.23	11.70	Y
5. Speed of addition	19.60	8.03	15.26	8.38	Y
6. Mechanical aptitude	34.08	7.06	30.19	6.15	Y
7. Verbal analogies	32.87	3.53	19.40	7.49	Y
B. Linguistic abilities:					
8. Vocabulary in context	36.88	2.33	23.93	7.48	Y
9. Vocabulary in isolation	35.62	2.59	24.09	7.05	Y
10. Range of information	34.12	3.11	23.39	6.34	Y
11. Phonetic association	65.47	22.42	37.37	21.63	Y
12. Word sense	47.37	18.57	21.15	14.68	Y
13. Homonymic meaning	37.41	10.87	24.34	8.50	Y
14. Prefixes	10.59	3.98	6.36	2.70	Y
15. Suffixes	8.16	3.83	5.56	2.84	Y
16. Latin and Greek roots	17.56	6.24	10.75	4.71	Y
17. Visual spelling recognition	26.05	6.64	20.69	5.97	Y
C. Verbal perception:					
18. Dot figure and ground	144.93	28.12	124.68	28.05	Y
19. Cue-symbol closure	66.79	13.00	56.52	13.82	Y
20. Word embedded	71.54	19.61	59.29	21.83	Y
21. Perception of reversals	80.70	21.59	72.17	18.55	Y
D. Listening comprehension:					
22. Auding	38.52	5.33	23.84	6.47	Y
E. Elements of musical ability:					
23. Tonal memory	22.90	5.90	18.58	5.38	Y
24. Tone-quality	28.45	4.80	25.59	5.48	Y
25. Tone-intensity	33.86	6.84	28.17	8.09	Y
26. Tonal movement	38.05	11.96	30.29	10.36	Y
27. Tone-time interval	23.17	5.71	21.91	4.98	N
28. Rythm	23.75	4.25	22.06	4.58	Y
29. Pitch	36.46	7.89	32.47	8.03	Y
30. Musical taste	27.24	6.19	23.34	7.14	Y

M

Table 19.—Comparison of means and standard deviations for powerful vs. nonpowerful readers on dependent and independent variables—Continued

Variable	Powerful mean	(N=108) Standard deviation	Nonpowerful mean	(N=108) Standard deviation	Significance of difference (1%)
Independent—Continued					
F. Academic attitudes-habits:					
31. School adustment and morale	52. 86	9. 94	47. 52	9. 06	Y
32. Scholarly values	49. 75	10. 05	48. 55	10. 19	N
33. Mechanics of study	51. 40	10. 40	49. 73	10. 40	N
34. Effective study plan	51. 79	11. 57	49. 71	10. 85	N
G. Interest:					
35. Outdoor interest	40. 00	15. 48	40. 27	14. 87	N
36. Mechanical interest	29. 90	13. 62	33. 65	12. 68	N
37. Computational interest	21. 72	9. 78	26. 70	7. 70	Y
38. Science interest	39. 79	14. 78	38. 97	13. 79	N
39. Persuasive interest	39. 28	12. 64	39. 58	10. 00	N
40. Artistic interest	30. 15	11. 38	28. 44	9. 84	N
41. Literary interest	22. 61	8. 98	17. 88	6. 43	Y
42. Musical interest	16. 69	7. 15	15. 80	8. 14	N
43. Social service interest	40. 89	14. 84	43. 31	12. 77	N
44. Clerical interest	45. 74	12. 89	54. 76	13. 37	Y
H. Emotional-social problems:					
45. School problems	5. 56	4. 11	7. 68	4. 12	Y
46. Postgraduation anxieties	10. 38	7. 45	13. 51	8. 69	Y
47. Problems with self	6. 84	7. 09	7. 61	6. 38	N
48. Problems with others	7. 47	6. 31	8. 13	6. 90	N
49. Home-family problems	5. 58	7. 42	5. 39	6. 75	N
50. Boy-girl problems	4. 44	4. 80	5. 02	5. 84	N
51. Health problems	3. 30	3. 49	3. 49	3. 35	N
52. Conflict in values	5. 84	6. 65	5. 44	6. 55	N
I. Musicality:					
53. Musical appreciation	30. 58	6. 32	27. 29	7. 01	Y
J. Age:					
54. Chronological age	197. 50	12. 58	197. 56	16. 60	N

Comparative Substrata Analyses for Power of Reading: Powerful vs. Nonpowerful

Table 20 presents a comparison of the zero-order coefficients of correlation of the independent variables with Power of Reading for the powerful and nonpowerful groups. The column on the right indicates that out of the 54 pairs of r's tested, only 5 show differences that are significant at the 1 percent level. In each case, the r's of the nonpowerful readers are larger, except for the relationship between Power of Reading and the number of problems reported in the home and family; here, the powerful readers' r is larger, but the sign is negative. The fewer the family problems, the more powerful the reader.

Powerful vs. Nonpowerful Readers at Level I: Power

Each of the matrices of 1,485 intercorrelations [2] for the two known-groups was submitted to a substrata analysis. Section A of table 21 reveals that word embedded contributes 11.3 percent, auding 9.4 percent, and verbal analogies another 7.5 percent, to account for 28.2 percent of individual differences in Power of Reading within a known-group of powerful readers. Section B shows that word embedded contributes 20.8 percent, vocabulary in context and isolation together account for 38.1 percent, and clerical interest 2.1 percent, to account for 61.0 percent of whatever it is that makes nonpowerful readers differ in their ability to read with power.

The finding that both groups utilize visual verbal perception (as assessed in the word embedded test) for success in within-group competition for Power of Reading is an unexpected discovery, because it did not appear as a primary substrata factor for the total group of 400.

Discovery of the word embedded test as a primary substrata factor underlying Power of Reading in both groups brings out the importance of visual-verbal perception in an area which is considered primarily cognitive and linguistic. This finding, coupled with the heavy reliance of the nonpowerful group upon both vocabulary in isolation and vocabulary in context, in contrast to the powerful group's utilization of auding and verbal analogies at Level I, *points directly to the basic premise of the Substrata-Factor Theory that excellence in Power of Reading is in the main an audiovisual verbal processing skill of symbolic reasoning.* The more powerful the reader, the greater his dependence upon verbal reasoning over and above his knowledge of words; the less powerful the reader, the greater his relative dependence upon knowledge of words.

---

[2] See Cooperative Research Project No. 538.

Table 20.—Comparison of zero-order coefficients of correlation of independent variables with Power of Reading for powerful vs. nonpowerful readers

Variable	Powerful (N=108) *r*	Nonpowerful (N=108) *r*	Significance of difference (1%)
Independent:			
A. Mental abilities:			
1. Visual verbal meaning	0.21	0.53	Y
2. Spatial relations	.25	.37	N
3. Inductive reasoning	.34	.40	N
4. Word fluency	.32	.26	N
5. Speed of addition	.19	.22	N
6. Mechanical aptitude	.18	.33	N
7. Verbal analogies	.35	.43	N
B. Linguistic abilities:			
8. Vocabulary in context	.39	.63	N
9. Vocabulary in isolation	.35	.65	Y
10. Range of information	.34	.58	N
11. Phonetic association	.20	.52	Y
12. Word sense	.30	.50	N
13. Homonymic meaning	.28	.46	N
14. Prefixes	.25	.31	N
15. Suffixes	.20	.31	N
16. Latin and Greek roots	.22	.50	N
17. Visual spelling recognition	.17	.60	Y
C. Verbal perception:			
18. Dot figure and ground	.17	.36	N
19. Cue-symbol closure	.20	.37	N
20. Word embedded	.40	.56	N
21. Perception of reversals	.10	.36	N
D. Listening comprehension:			
22. Auding	.41	.44	N
E. Elements of musical ability:			
23. Tonal memory	.21	.33	N
24. Tone-quality	−.05	.27	N
25. Tone-intensity	.13	.34	N
26. Tonal movement	.16	.24	N
27. Tone-time interval	.16	.18	N
28. Rhythm	.04	.32	N
29. Pitch	.12	.30	N
30. Musical taste	.04	.10	N
F. Academic attitudes-habits:			
31. School adjustment and morale	.23	.03	N
32. Scholarly values	.19	.07	N
33. Mechanics of study	.09	.12	N
34. Effective study plan	.22	.10	N

Table 20.—Comparison of zero-order coefficients of correlation of independent variables with Power of Reading for powerful vs. nonpowerful readers—Continued

Variable	Powerful (N=108) r	Nonpowerful (N=108) r	Significance of difference (1 %)
Independent—Continued			
G. Interests:			
35. Outdoor	0. 07	−0. 03	N
36. Mechanical	−. 08	−. 01	N
37. Computational	. 12	−. 06	N
38. Science	. 10	. 10	N
39. Persuasive	−. 20	. 12	N
40. Artistic	−. 01	. 10	N
41. Literary	. 07	. 00	N
42. Musical	−. 05	. 04	N
43. Social service	−. 05	. 11	N
44. Clerical	. 04	. 12	N
H. Emotional-social problems:			
45. School problems	−. 17	−. 13	N
46. Postgraduation anxieties	−. 12	. 06	N
47. Problems with self	−. 15	. 07	N
48. Problems with others	−. 18	. 05	N
49. Home-family problems	−. 24	. 12	Y
50. Boy-girl problems	−. 14	. 11	N
51. Health problems	−. 09	. 21	N
52. Conflict in values	. 06	. 09	N
I. Musicality:			
53. Musical appreciation	. 07	. 25	N
J. Age:			
54. Chronological age	. 09	−. 09	N

The flowcharts, figures 21 and 22, depict the hierarchical arrangement of the substrata factors underlying Power of Reading at Levels I, II, and III for the powerful and nonpowerful known-groups of readers.[3]

Powerful vs. Nonpowerful Readers at Level II: Power

The following preferential predictors, pages 126 and 127, abstracted from the flowcharts in figures 21 and 22 compare the substrata elements underlying the substrata factors precipitated at Level I.

---

[3] Detailed charts, tables, and other data upon which these figures are based are recorded in Cooperative Research Project No. 538.

Table 21.—Comparative analyses of powerful vs. nonpowerful readers yielding accounted-for variance in Power of Reading

Criterion Level 0	Substrata factor Level I	Zero-order r	Beta β	Cumulative $\overline{R}$	Contribution to variance accounted for (in percent)	
					Adjusted	Total
A. Powerful (N=108)						
Power of Reading	Auding	0. 41	0. 25	0. 399	9. 4	
	Word embedded	. 40	. 30	. 493	11. 3	
	Verbal analogies	. 35	. 22	. 531	7. 5	28. 2
B. Nonpowerful (N=108)						
Power of Reading	Vocabulary in isolation	0. 65	0. 29	0. 643	18. 6	
	Word embedded	. 56	. 38	. 744	20. 8	
	Vocabulary in context	. 63	. 32	. 762	19. 5	
	Clerical interest	. 12	. 18	. 782	2. 1	61. 0

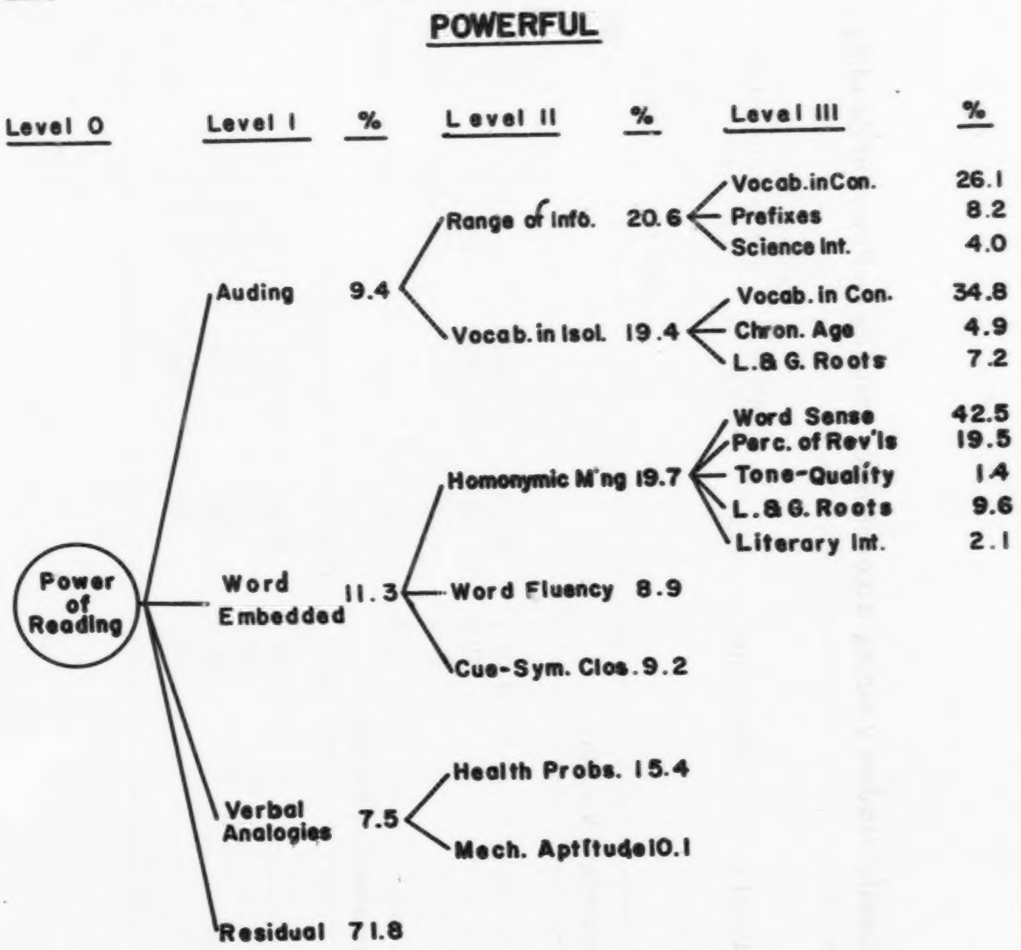

POWERFUL
Level 0
Level I
%
Level II
%
Level III
%
Power of Reading
Auding 9.4
Range of Info. 20.6
Vocab.inCon. 26.1
Prefixes 8.2
Science Int. 4.0
Vocab. in Isol. 19.4
Vocab. in Con. 34.8
Chron. Age 4.9
L.& G. Roots 7.2
Word Embedded 11.3
Homonymic M'ng 19.7
Word Sense 42.5
Perc. of Rev'ls 19.5
Tone-Quality 14
L.& G. Roots 9.6
Literary Int. 2.1
Word Fluency 8.9
Cue-Sym. Clos. 9.2
Verbal Analogies 7.5
Health Probs. 15.4
Mech. Aptitude 10.1
Residual 71.8

Figure 21.—Flowchart for Power of Reading for the 108 most powerful readers.

For Power of Reading at *Level 0*

	Percent variance accounted for—	
	Powerful	*Nonpowerful*
Underlying Auding Factor at *Level I* is found—		
At *Level II* (see fig. 21):		
Range of information	20. 6	-----
Vocabulary in isolation	19. 4	-----
Underlying Word Embedded Factor at *Level I* is found—		
At *Level II* (see figs. 21 and 22):		
Homonymic meaning	19. 7	-----
Word fluency	8. 9	-----
Cue-symbol closure	9. 2	19. 6
Visual spelling recognition	----	14. 2
Perception of reversals	----	9. 8
Underlying Verbal Analogies Factor at *Level I* is found—		
At *Level II* (see fig. 21):		
Health problems	15. 4	-----
Mechanical aptitude	10. 1	-----

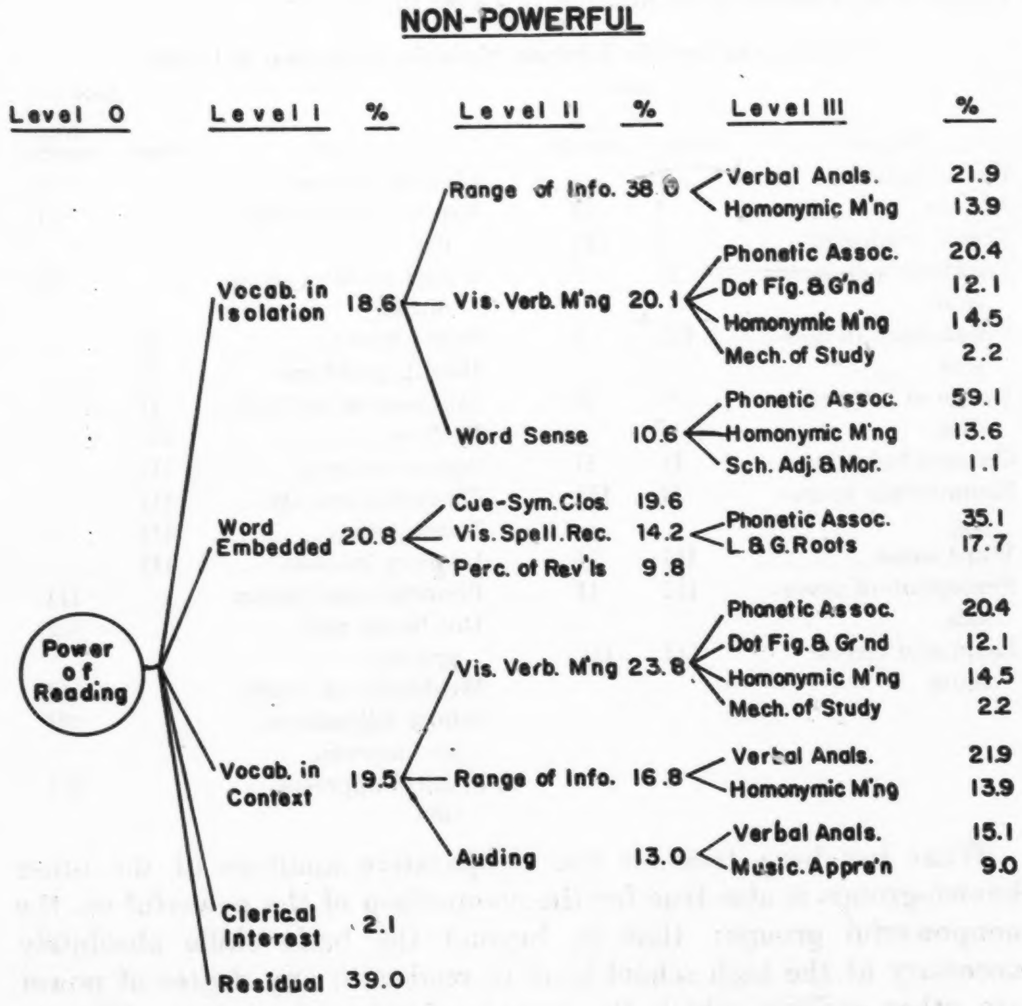

NON-POWERFUL
Level 0
Level I
%
Level II
%
Level III
%
Power of Reading
Vocab. in Isolation 18.6
Range of Info. 38.0
Verbal Anals. 21.9
Homonymic M'ng 13.9
Vis. Verb. M'ng 20.1
Phonetic Assoc. 20.4
Dot Fig. & G'nd 12.1
Homonymic M'ng 14.5
Mech. of Study 2.2
Word Sense 10.6
Phonetic Assoc. 59.1
Homonymic M'ng 13.6
Sch. Adj. & Mor. 1.1
Word Embedded 20.8
Cue-Sym. Clos. 19.6
Vis. Spell. Rec. 14.2
Phonetic Assoc. 35.1
L. & G. Roots 17.7
Perc. of Rev'ls 9.8
Vocab. in Context 19.5
Vis. Verb. M'ng 23.8
Phonetic Assoc. 20.4
Dot Fig. & Gr'nd 12.1
Homonymic M'ng 14.5
Mech. of Study 2.2
Range of Info. 16.8
Verbal Anals. 21.9
Homonymic M'ng 13.9
Auding 13.0
Verbal Anals. 15.1
Music. Appre'n 9.0
Clerical Interest 2.1
Residual 39.0

Figure 22.—Flowchart for Power of Reading for the 108 nonpowerful readers.

For *Power of Reading* at *Level 0*—Continued

	Percent variance accounted for—	
	Powerful	*Nonpowerful*
Underlying Vocabulary in Isolation Factor at *Level I* is found—		
At *Level II* (see fig. 22):		
Range of information	----	38.0
Visual verbal meaning		20.1
Word sense		10.6
Underlying Vocabulary in Context Factor at *Level I* is found—		
At *Level II* (see fig. 22):		
Visual verbal meaning	----	23.8
Range of information	----	16.8
Auding	----	13.0

Powerful vs. Nonpowerful Readers at Level III: Power

Common and Specific Substrata Variables Regardless of Levels

	Level	
Common	*Power*	*Non-powerful*
Word embedded	I	I
Auding	I	II
Verbal analogies	I	III
Vocabulary in isolation.	II	I
Vocabulary in context.	III	I
Range of information.	II	II
Cue-symbol closure	II	II
Homonymic meaning.	II	III
Word sense	III	II
Perception of reversals.	III	II
Latin and Greek roots.	III	III

	Level	
Specific	*Power*	*Non-powerful*
Clerical interest	----	I
Visual verbal meaning.	----	II
Visual spelling recognition.	----	II
Word fluency	II	----
Health problems	II	----
Mechanical aptitude	II	----
Prefixes	III	----
Science interest	III	----
Chronological age	III	----
Tone-quality	III	----
Literary interest	III	----
Phonetic association	----	III
Dot figure and ground.	----	III
Mechanics of study	----	III
School adjustment and morale.	----	III
Musical appreciation.	----	III

What has been true for the comparative analyses of the other known-groups is also true for the comparison of the powerful vs. the nonpowerful groups: that is, beyond the basic skills absolutely necessary at the high school level to read with any degree of power are other abilities which the most sophisticated readers utilize to achieve extraordinary success.

Let us theorize on these findings: Most interesting in the common column are the identical levels held by certain factors (word embedded, range of information, and cue-symbol closure) and the differential in levels for other factors (relatively high levels for the powerful are held by auding, verbal analogies, and homonymic meaning, and for the nonpowerful by vocabulary in isolation, vocabulary in context, word sense, and perception of reversals). Word embedded, cue-symbol closure, and perception of reversals all have to do with speed of visual-verbal closure and the perceptual ability to abstract figure from ground. These Gestalt principles of visual perception are very prominently displayed in the working-systems of both the powerful and the nonpowerful readers. Their appearance in the working-systems of the extremely powerful *and* nonpowerful groups, together with the differentials in location of the other substrata factors, suggests the hypothesis that these abilities are being used by the two groups in totally different ways. It is therefore hypothesized that these perceptual principles are used by the nonpowerful readers to guess the meaning of unknown or barely recognized words as a supplement to their direct dependence on knowledge of vocabulary, whereas the powerful readers utilize the structural configuration of word patterns directly for the rapid recognition of the meaning of whole phrases. In the nonpowerful group, visual perception of configuration is an important help in deciphering the meaning of words; in the powerful group, to recognize a configuration is to understand its meaning. Here we have a theoretical explanation of what is happening in the lower grades when some students taught by the look-say method are still at a look-and-*guess* level, while others have already reached the look-and-*figure-out* stage, and the best students have developed to where they look-and *know!*

SECTION IV

THE CENTROID FACTOR ANALYSES

Chapter XI. A Centroid Factor Analytic Study of Reading Abilities for the Total Group of High School Students

The Problem and Related Research

The analyses reported in this and the next chapter had several objectives: (*a*) to discover by the traditional centroid factor analysis (Thurstone, 1947) the factorial structure of the matrices upon which the substrata-factor analyses of Speed and Power of Reading were made in previous chapters; (*b*) to isolate and define the factors involved in Speed and Power of Reading; and (*c*) to relate the results of the substrata-factor analysis reported in chapter VI to the results herein obtained from the centroid factor analyses.

Summary of Related Research

Traditionally, what has the technique known as factor analysis revealed about the reading problem? Taken in toto, evidence offered by Gans (1940), Langsam (1941), Johnson and Reynolds (1941), Davis (1942), Conant (1942), Hall and Robinson (1945), and Crook (1957) indicates that a factor of major import seems to be something which could be called a *verbal factor concerned with ideas and meanings.* Singer's (1960) study corroborates this finding and further differentiates the domain into a visual verbal and auditory verbal comprehension factor.

Pressey and Pressey (1921), Langsam (1941), Conant (1942), and Hall and Robinson (1945) indicate that reading ability has a loading on a *knowledge of word meanings factor.*

Attitudes, either making for a characteristic type of reader or as alternative mental sets in the same individual, have been found important by Pressey and Pressey (1921), Feder (1938), Gans (1940), and Hall and Robinson (1945). The *study attitude factor*, therefore, seems to be a necessary ingredient for comprehension and accuracy while reading.

A *perceptual factor*, indicated by Langsam (1941) and Singer (1960), seems closely related to Feder's (1938) perceptual ability factor.

A *memory factor* is discussed by Gans (1940) and inferred by Davis (1942).

Johnson and Reynolds (1941) define a *flow of various responses factor* which is apparently not unlike Langsam's (1941) factor indicating word fluency and Davis' (1942) factor concerning ability to select the appropriate meaning for a word or a phrase in the light of a particular contextual setting.

Hall and Robinson (1945) indicate a *chart reading factor*, and this is probably closely related to Conant's (1942) *specific intellectual factor* and Langsam's (1941) *number factor*.

As may be seen by the above brief summary of the literature, the factor analytic approach has made certain inroads into the nature of reading, and from a particular point of view has tried to solve the problem raised by Lazar (1942): to discover the most significant elements in the combination of many which are fundamental to success or failure in the reading process.

A Centroid Factor Analysis of the Correlation Matrix for the Total Sample

The purpose of the present analysis was to assess a number of domains which were not included in the reading test criteria per se, but are closely related to success in reading. It was expected, on the bases of previous studies by Holmes (1948, 1953, 1954, 1957, 1961), that reading Speed and Power would have substantial loadings upon those factors which represent the following psychoeducational domains:

Hypothecated Domains

Auditory Perception and Elements of Auditory Images:
a. Tonal memory
b. Tone-quality
c. Tone-intensity
d. Tone-time interval
e. Rhythm
f. Pitch

Auditory Cognition and Comprehension:
a. Auding ability
b. Musical appreciation
c. Musical taste
d. Tonal movement

Visual Perception:
a. Dot figure and ground
b. Cue-symbol closure
c. Word embedded
d. Perception of reversals
e. Spatial relations

Verbal Relationships (Visual and Auditory):
a. Visual verbal meaning
b. Vocabulary in context
c. Vocabulary in isolation
d. Phonetic association
e. Homonymic meaning
f. Latin and Greek roots
g. Visual spelling recognition
h. Prefixes and suffixes

Symbolic Reasoning:
a. Inductive reasoning
b. Word fluency
c. Speed of addition
d. Mechanical aptitude
e. Verbal analogies
f. Word sense

Interest:

- a. Outdoor interest
- b. Mechanical interest
- c. Computational interest
- d. Science interest
- e. Persuasive interest
- f. Artistic interest
- g. Literary interest
- h. Musical interest
- i. Social service interest
- j. Clerical interest

School Adjustment and Personal Problems:

- a. School adjustment and morale
- b. Scholarly values
- c. Mechanics of study
- d. Effective study planning and deliberation
- e. Personal problems:
  - School problems
  - Postgraduation anxieties
  - Problems with self
  - Problems with others
  - Home-family problems
  - Boy-girl problems
  - Health problems
  - Problems with things in general

Maturation:

- a. Chronological age
- b. Range of information

Treatment of the Data

The correlation matrix shown in table 4 was analyzed by means of the IBM 701 Centroid Factor Analytic Program, No. 463.[1] This program automatically inserts the largest correlation of the column into the diagonal of the matrix and reflects the necessary variables to achieve a positive manifold for the original and for each residual matrix. Factoring was continued until the largest residual off-diagonal element was less than 0.09.

All those factors which met Humphrey's rule were accepted for rotation; that is, all the factors were accepted in which the cross-products of the two largest loadings in a vector were equal to, or less than, twice the standard error of a zero-order correlation coefficient of the original correlation matrix. To be conservative, two additional vectors were also included in the rotation. In all, nine vectors were extracted and entered into the Kaiser Normalized Varimax Rotation Program for the 701 Digital Computer (1953, Program No. 464).[1]

The Kaiser Program rotates factors until they achieve maximum interpretability. In a normalized solution, the Varimax Technique augments each vector to unity and then rotates until it is not possible to make any further rotation that is greater than 1 minute. When convergence to this criterion has been achieved, the augmented vectors are returned to their original length. This augmentation means that the rotation is not influenced by the length of the original vectors. Table 22 presents the rotated factor loadings, test communalities, and percent of common factor variance accounted for by each factor.

---

[1] Program Number, Computer Center, University of California at Berkeley.

Interpretation of the Factors

Table 22 presents the rotated factors in the order in which they were successively precipitated in the centroid factor analysis. The following interpretations rest principally on those tests with loadings of plus or minus 0.28 or greater.

Factor I. From the arrayed test loadings on Factor I (abstracted from table 22) given below, it is obvious that this is a very complex *audiovisual verbal factor of word knowledge, understanding, and symbolic reasoning.*

I. Audiovisual Verbal Symbolic-Reasoning Factor

Variable	*Loading*	*Variable*	*Loading*
Vocabulary in isolation	0.84	Homonymic meaning	0.52
Vocabulary in context	.83	Latin and Greek roots	.49
Power of Reading	.81	Phonetic association	.46
Range of information	.81	Prefixes	.45
Auding ability	.81	Inductive reasoning	.40
Verbal analogies	.72	Visual spelling recognition	.38
Visual verbal meaning	.68	Suffixes	.35
Speed of Reading	.66	Literary interest	.33
Word sense	.56	Dot figure and ground	.31

Both Power and Speed of Reading have high loadings on this factor, but the factor by no means extracts all the variance of these two tests. However, Factor I accounts for 66 percent of the variance in Power and 44 percent for that in Speed of Reading (0.81 and 0.66 squared, respectively). Altogether, 27.3 percent of the total matrix variance is accounted for by this factor.

Factor II. Factor II is a *personal problems or maladjustment factor*. From the tabulation below, it will be noted that "problems with others" has a very high loading on this factor. Each of the other problems assessed by the SRA Youth Inventory also has high loadings.

II. Personal Problems or Maladjustment Factor

Variable	*Loading*	*Variable*	*Loading*
Problems with others	0.86	Conflict in values	0.71
Problems with self	.78	School problems	.69
Boy-girl problems	.77	Postgraduation anxieties	.65
Health problems	.74	Home-family problems	.58

Since Power and Speed of Reading have negative loadings of insignificant magnitude, i.e., −0.01 and −0.06, respectively, this general Personal Problems Factor cannot be used to explain the variance in Speed or Power of Reading. Nevertheless, Factor II accounts for 16.2 percent of the total common variance extracted from the matrix.

Factor III. Factor III appears to be a *sex-role interest factor*. The reason for identifying this factor as such rests in the fact that it is bipolar and appears to contrast, in terms of the high positive and high negative loadings, those culturally expected interests expressed on the one hand by boys and on the other, by girls.

III. *Sex-Role Interest Factor*

Variable	*Loading*	*Variable*	*Loading*
Outdoor interest	0. 69	Musical interest	−0. 31
Mechanical interest	. 61	Literary interest	−. 32
Science interest	. 60	Persuasive interest	−. 48
Mechanical aptitude	. 52	Clerical interest	−. 56

Power and Speed of Reading load only 0.00 and −0.07, respectively, on this factor. It is apparent, then, that this particular set of interest tests defines, for our sample of boys and girls, a clear-cut factor; but in itself, this sex-role interest factor is not related to the ability to read with speed or power. Factor III accounts for 9.1 percent of the total factor variance extracted from this matrix.

Factor IV. From the arrayed loadings, it is evident that this factor has to do especially with the analysis of word meaning, which depends upon the meaning carried by structural elements and the audiovisual discrimination of small, but significant, differences in phonetic elements. Therefore, this has been labeled a *phonetic word-structure factor*.

IV. *Phonetic Word-Structure Factor*

Variable	*Loading*	*Variable*	*Loading*
Phonetic association	−0. 69	Prefixes	−0. 47
Word sense	−. 67	Suffixes	−. 40
Homonymic meaning	−. 61	Perception of reversals	−. 39
Visual spelling recognition	−. 51	Latin and Greek roots	−. 39

Teachers are generally agreed that the abilities showing a high loading on Factor IV are important in reading. It is evident from the substrata factor analysis that these variables actually play an important part in Speed and Power of Reading, especially at the second and third levels. It comes as somewhat of a surprise, therefore, to see that Speed and Power of Reading load only −0.17 and −0.07, respectively, on this factor. We have here a vivid example of how a particular shortcoming of a centroid factor analysis is, in fact, a particular strength of a substrata-factor analysis. For while the factor itself accounts for 10.3 percent of the total common variance extracted from the matrix, it accounts for only a little less than 0.5

Table 22.—Loadings on Varimax rotated centroid factors for total group, N=400

	Variables	Rotated factor loadings									H. sq.
		1	2	3	4	5	6	7	8	9	
S.	Speed of Reading	66	−06	−07	−17	−16	26	06	15	−09	60
P.	Power of Reading	81	−01	−00	−07	−26	16	00	01	03	76
01	Visual verbal meaning	68	−06	01	−26	−24	31	05	06	−02	69
02	Spatial relations	23	−02	22	−09	−18	38	−08	−32	−07	39
03	Independent reasoning	40	−03	−06	−16	−38	47	03	−10	−19	60
04	Word fluency	24	−02	−02	−10	−22	32	03	16	06	24
05	Speed of addition	09	−09	−02	−19	−25	43	17	−10	02	34
06	Mechanical aptitude	27	−02	52	−07	−18	08	03	−39	−05	54
07	Verbal analogies	72	−09	11	−07	−24	13	−13	−21	−07	68
08	Vocabulary in context	83	−04	03	−15	−19	10	−15	−06	14	81
09	Vocabulary in isolation	84	−04	04	−13	−20	08	−10	−06	14	80
10	Range of information	81	−02	07	−10	−18	06	−04	−18	04	75
11	Phonetic association	46	−06	−08	−69	−19	18	−10	10	02	78
12	Word sense	56	−04	−01	−67	−15	20	−00	16	02	85
13	Homonymic meaning	52	−04	−04	−61	−09	28	10	05	−01	75
14	Prefixes	45	−06	07	−47	−13	19	19	11	−03	53
15	Suffixes	35	00	05	−40	−08	18	20	06	−13	38
16	Latin and Greek roots	49	−04	04	−39	−12	24	28	04	−11	55
17	Visual spelling recognition	38	−08	−14	−51	−05	37	07	07	19	62
18	Dot figure and ground	31	−06	14	−12	−11	53	−16	−03	−04	45

19	Cue-symbol closure	25	−05	21	−18	−14	53	−14	−22	06	51
20	Word embedded	22	−06	01	−24	−18	61	02	14	06	54
21	Perception of reversals	07	−12	−03	−39	−17	48	07	−04	18	47
22	Auding	81	−08	09	−05	−20	07	06	−05	−06	72
23	Tonal memory	19	−06	01	−08	−62	19	−02	−08	−11	48
24	Tone-qualtiy	11	01	03	−00	−64	10	07	−05	−01	44
25	Tone-intensity	20	08	05	−02	−62	12	10	−03	−03	46
26	Tonal movement	20	−02	−01	−07	−54	14	−02	−05	−21	39
27	Tone-time interval	04	−00	04	05	−52	03	11	−07	−04	30
28	Rhythm	12	04	01	−12	−57	−00	−06	08	−02	36
29	Pitch	15	−01	02	−13	−62	11	−03	−07	09	45
30	Musical taste	11	−04	06	−06	−56	10	00	12	12	37
31	School adjustment and morale	24	−17	−08	−17	−10	−00	06	−07	−18	17
32	Scholarly values	02	−06	−12	−19	−10	03	05	−06	−09	08
33	Mechanics of study	06	−11	00	−08	−03	07	05	−06	21	08
34	Effective study plan	05	−07	02	−09	−06	12	28	03	01	11
35	Outdoor interest	01	−02	69	09	−01	04	−01	−04	−08	49
36	Mechanical interest	−13	01	61	08	−02	05	06	−41	−00	56
37	Computational interest	−17	−03	10	03	04	01	53	−45	12	55
38	Science interest	07	−01	60	04	−04	−04	41	−11	08	56
39	Persuasive interest	02	01	−48	05	04	−01	−10	−02	−08	25
40	Artistic interest	00	04	−08	−01	−01	17	−48	03	03	27
41	Literary interest	33	−04	−32	−08	07	−07	09	02	06	24
42	Musical interest	−02	−07	−31	−04	−23	−06	−12	08	−05	18
43	Social service interest	−09	10	−11	−04	00	−03	−04	46	−05	25

Table 22.—Loadings on Varimax rotated centroid factors for total group, N=400—Continued

Variables	Rotated factor loadings									H. sq.
	1	2	3	4	5	6	7	8	9	
44 Clerical interest	−22	06	−56	02	10	03	22	−28	08	51
45 School problems	−22	69	−00	08	05	−01	−08	−10	−17	57
46 Postgraduation anxieties	−13	65	−00	01	−00	−12	04	−10	13	47
47 Problems with self	−04	78	−01	10	01	01	−03	04	−11	64
48 Problems with others	−05	86	04	03	01	−04	−05	−04	−10	76
49 Home-family problems	06	58	−02	03	03	08	−09	00	−10	37
50 Boy-girl problems	−04	77	−00	−05	−02	−19	−04	03	13	65
51 Health problems	00	74	−03	04	01	04	04	14	00	57
52 Conflict (values)	03	71	02	−04	−03	−11	02	20	09	57
53 Musical appreciation	14	−05	−01	−08	−57	02	−13	05	21	41
54 Chronological age	−10	−00	07	−04	05	14	18	17	10	11
Sum loadings squared	7. 4	4. 4	2. 5	2. 8	4. 1	2. 8	1. 3	1. 4	0. 6	27. 3
Percent common variance	27. 3	16. 2	9. 1	10. 3	14. 9	10. 1	4. 8	5. 2	2. 2	100. 0

percent of the variance for Power and slightly less than 3.0 percent of the variance for Speed of Reading. This raises another important point, namely the relationship between Factor I, *Verbal Knowledge and Symbolic Reasoning*, and Factor IV, the *Phonetic Word-Structure Factor*. All the tests that have high loadings on Factor IV also have relatively high loadings on Factor I, the very factor that saturates the Speed and Power of Reading tests. How is it possible for this to be so?

It appears that while the fourth factor is a phonetic word-structure factor, its relation to reading is dependent upon the interfacilitation of the phonetic word-structure elements only after they have been woven together in terms of total words and word patterns; that is, reasoning enters into both perception and comprehension. Of course, the interfacilitation process just hypothesized cannot be inferred from the centroid factor analysis, but emerges when one contrasts and compares the findings of the centroid factor analysis with those of the substrata factor analysis. It is obvious then that the two analyses present complementary aspects of the same audiovisual verbal processing skills upon which symbolic reasoning is dependent in the act of reading.

Further, it means, in terms of the Substrata-Factor Theory, that each of the tests that entered into both centroid Factors IV and I are simply more comprehensive than what was required from them in the Speed and Power of Reading tests used. That they "hang" together is shown by their loadings in both factors and therefore another set of criteria tests for speed and power of reading would certainly have drawn on more or less of these tests. That is, it should be realized that all the individual's knowledge in each of these areas stands ready to do yeoman service in the reading task if and when the occasion arises.

Factor V. From the loadings tabulated below, it can be seen why Factor V is identified as an *auditory-perceptual factor*.

V. Auditory-Perceptual Factor

Variable	*Loading*	*Variable*	*Loading*
Tone-quality	−0. 64	Rhythm	−0. 57
Tone-intensity	−. 62	Musical taste	−. 56
Tonal memory	−. 62	Tonal movement	−. 54
Pitch	−. 62	Tone-time interval	−. 52
Musical appreciation	−. 57	Inductive reasoning	−. 38

It is obvious then that Factor V includes not only all the tests listed in the domain of "auditory perception and elements of auditory images," but also those, except for auding, that were postulated in the auditory cognitive and comprehension domains. The fact that auding ability does *not* have a substantial loading on this factor, and yet has a high loading on Factor I, is proof that auding ability is in the realm of symbolic manipulation of audioverbal relationships, rather than in the domain of audio-perceptual discriminations.

Power of Reading loads −0.26; consequently, Factor V accounts for 6.76 percent of its variance. Speed loads −0.16; its variance is accounted for to the extent of 2.56 percent. Therefore, by working in Factor V, these auditory perceptual elements enter directly and significantly into Power and Speed of Reading. Since auding loads 0.20 on this factor, some of these auditory elements must also function in listening comprehension.

Factor VI. Factor VI has been identified as a *speed of visual-verbal perception factor*, inasmuch as the tests having the highest loadings on this factor measure, through the visual modality, perceptual speed, and discrimination in the use of the visual form of verbal symbols.

VI. *Speed of Visual-Verbal Perception Factor*

Variable	*Loading*	*Variable*	*Loading*
Word embedded	0.61	Spatial relations	.38
Cue-symbol closure	.53	Visual spelling recognition	.37
Dot figure and ground	.53	Word fluency	.32
Perception of reversals	.48	Visual verbal meaning	.31
Inductive reasoning	.47	Homonymic meaning	.28
Speed of addition	.43		

This speed of visual-verbal perception factor seems to assess both the flexibility and sustainability of verbal figure closure against a verbal matrix background. Speed of Reading loads 0.26, whereas Power of Reading loads 0.16 on this factor. This factor, then, accounts for 6.76 percent of the variance for Speed and 2.56 percent for Power of Reading. Factor VI accounts for 10.1 percent of the total common variance extracted from the matrix.

Factor VII. Considering its bipolarity, Factor VII is identified as having to do with structural orderliness versus creative orderliness—a desire for numerical regularity versus a desire for variety within regularity. This contrast has led tentatively to identifying this as a *systematization interest factor* with which artistic interest would have a high negative correlation.

VII. *Systematization Interest Factor*

Variable	*Loading*	*Variable*	*Loading*
Computational interest	0.53	Artistic interest	−0.48
Science interest	.41		
Latin and Greek roots	.28		
Effective study plan	.28		

Power of Reading has a zero loading on this factor, while Speed of Reading loads 0.06. The total common variance that Factor VII accounts for in the matrix is 4.8 percent.

Factor VIII. Factor VIII has been interpreted as a *mechanical interest factor*. Judging from the tabulations below, it may be seen that the domain of interest is obviously a complex one; Factor VIII is distinct from Factors III and VII, already reviewed.

Test Loadings on the 3 Interest Factors

Test Name	Factor III, Sex-Role Interest	Factor VII, Systematization Interest	Factor VIII, Mechanical Interest
Outdoor interest	0.69	−0.01	−0.04
Mechanical interest	.61	.06	−.41
Science interest	.60	.41	−.11
Mechanical aptitude	.52	.03	−.39
Computational interest	.10	.53	−.45
Spatial relations	.22	−.08	−.32
Clerical interest	(1)	.22	−.28
Speed of Reading	−0.07	0.06	0.15
Power of Reading	−.00	.00	.01
Literary interest	−0.32	0.09	0.02
Clerical interest	−.56	(1)	(1)
Artistic interest	−.08	−.48	.03
Persuasive interest	−.48	−.10	−.02
Social service interest	−.11	−.04	.46
Musical interest	−.31	−.12	.08

[1] Clerical interest tabulation split to fit appropriately into the comparative categories.

It may be reasoned from the differential loadings tabulated above that the hypothesized general interest domain has been broken down by the centroid factor analysis into three separate realms that are relatively independent of one another. Factor III is thought of as a sex-role interest factor; Factor VII, the systematization and numerical ordering of events factor; and Factor VIII has to do with interest in mechanical things versus interest in people. The linkage in the contrasting interest patterns of these three factors seems to be in the mechanical, science interest, mechanical aptitude, and computational interest areas.

Factor VIII loads only 0.01 for Power and 0.15 for Speed of Reading. The factor accounts for 5.2 percent of the common variance extracted from the matrix.

Factor IX. The loadings on Factor IX are so low as to preclude its identification. Furthermore, it accounts for only 2.2 percent of the common factor variance extracted from the matrix. Perhaps this low percent indicates that one too many vectors were extracted for the rotation.

Summary

The factorial space in the battery of tests may be defined in terms of the following eight interpretable dimensions:

I. A verbal knowledge and symbolic reasoning factor
II. A personal problems or maladjustment factor
III. A bipolar, culturally expected, sex-role interest factor
IV. A phonetic word-structure factor
V. An audioperceptual factor
VI. A speed of visual-verbal perception factor
VII. A systematization or numerical ordering factor
VIII. A mechanical interest factor

It will be recalled that this centroid factor analysis began by posing 2 major hypotheses: (*a*) that certain factors would emerge in the analysis of our 54 independent tests, and (*b*) Speed and Power of Reading would load on each of these factors. A comparison of the domains postulated on an a priori basis and the actual factors empirically extracted from our matrix indicates that some of the specific hypotheses were supported, and some were not. For instance, the hypothecated domain of *maturation did not emerge*, and chronological age did not have a significant loading on any of the factors. Furthermore, the four study methods tests are apparently independent of the eight factors accounting for the common variance in our matrix and are also orthogonal to one another, for they did not in themselves emerge as a single identifiable factor.

Contrary to anticipation, scrutiny of the loadings in the rotated factors in table 22 shows that Speed and Power of Reading did not load significantly on all of the emerging factors. They had "significant" loadings only on the first, verbal knowledge and symbolic reasoning factor; however, Speed of Reading had a loading of 0.26 on the speed of visual-verbal perception factor, and Power of Reading had a loading of 0.26 that was consonant with the audioperceptual factor. These last two loadings seem to be in agreement with the results found by Singer (1960) at the fourth-grade level.

Table 23 shows the extent to which each of the rotated centroid factors saturates the criteria, Speed and Power of Reading, for the total group.

So far as the correlation matrix is concerned, Centroid Factors I, IV, V, VI, and VIII account for most of the explainable variance in Speed; and Centroid Factors I, V, and VI do so for Power of Reading. Together, *all nine factors* account for 60 percent of the common variance in Speed and 76 percent in Power of Reading for the total group.

Table 23.—Centroid factor loadings for Speed and Power of Reading

Factor	Loading	
	Speed	Power
I. Audiovisual verbal symbolic-reasoning	0. 66	0. 81
II. Personal problems	—. 06	—. 01
III. Sex-role interest	—. 07	—. 00
IV. Phonetic word-structure	—. 17	—. 07
V. Auditory-perceptual	—. 16	—. 26
VI. Speed of visual-verbal perception	. 26	. 16
VII. Systematization interest	. 06	. 00
VIII. Mechanical interest	. 15	. 01
IX. Unidentified	—. 09	. 03

Chapter XII. A Comparative Centroid Factor Analytic Study of Known-Groups

Introduction

The purpose of the centroid factor analyses of the known-groups was (*a*) to determine the factors that account for the variance in the correlation matrix of each, (*b*) to compare these centroid factors, and (*c*) to interpret the factor patterns for Speed and Power of Reading in each of the known-groups.

Hypothesis: Known-groups (boys, girls, fast, slow, powerful, and nonpowerful readers), selected from the total sample of 400 high school students,[1] will draw upon different factors and/or different amounts of the same set of centroid factors to achieve Speed and/or Power in Reading.

Procedure

The centroid factor analyses for the known-groups followed the same procedure as for the total sample. Using the same criteria, nine centroid factors were extracted from the correlation matrix of each known-group and rotated by Kaiser's Normalized Varimax technique to attain maximum interpretability. The arrays of loadings were inspected, and each factor, if interpretable, was defined. Those factors on which Speed or Power of Reading loaded were then used to explain individual differences in the criteria. Finally, a comparative analysis was made for the total and known-groups.

Results

The identified factors are summarized in table 24. The sums of the squared loadings have been entered in the cells to indicate the extent to which each factor accounts for the common variance in each group's matrix. Where no entry appears, the factor was not defined for that particular group. The table shows that (*a*) seven factors are common to all groups; (*b*) some factors are common to two or more groups; (*c*) the word-part analytic interest factor is specified to the boys' group; (*d*) finally, one or more nonidentifiable factors, all of which have low loadings and account for a very small percent of the common variance, are found in most groups.

---

[1] A centroid factor analysis of the total group is reported in chap. XI.

Table 24.—Summary of centroid factors with percent of common variance accounted for in the matrix of each known-group

[In percent]

Factors extracted	Total	Boys	Girls	Fast	Slow	Powerful	Non-powerful
I. Audiovisual verbal symbolic-reasoning	27	26	25	21	21	13	26
II. Personal problems	16	16	16	18	16	17	17
III. Sex-role interest	9	8	7	11	10	8	7
IV. Phonetic word-structure	10	10	15	14	17	19	6
V. Auditory-perceptual	15	16	13	10	15	15	16
VI. Speed of visual-verbal perception	10	11	9	10	6	8	8
VII. Systematization interest	5	5	5	6	6	6	6
VIII. Mechanical interest	5	------	------	------	------	------	------
IX. Interest in things	------	------	------	------	------	7	10
X. Word-part analytic interest	------	4	------	------	------	------	------
XI. School adjustment (academic and/or social)	------	------	5	------	------	6	4
Noninterpretable	2	4	4	5	4	------	------
Noninterpretable	------	------	------	5	4	------	------

Identification and Interpretation of Factors

Figure 23 presents a three-dimensional paradigm of the design followed in the present analyses. It should be noted that table 24 represents for each "factor by group" column a top-to-bottom summation over all the tests.

In the comparative analyses, sectional slices representing "factor by tests" were taken successively from the face of the block. In this way, each factor in turn was separately analyzed to show the resemblance of the loadings for each known-group on all the important tests of the factor in question. The comparability of an identified factor in terms of the loadings for the important tests for each of the known-groups becomes self-evident upon inspection.

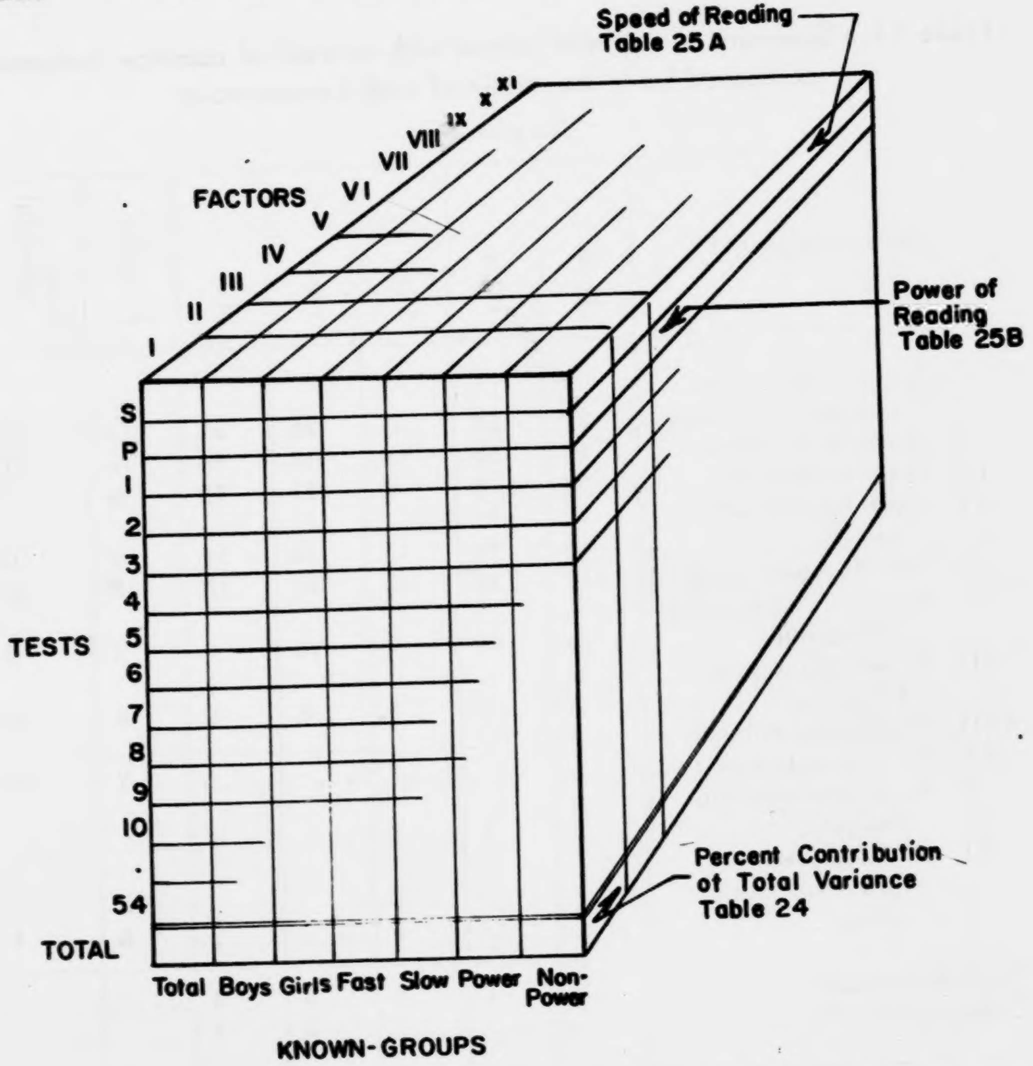

Speed of Reading
Table 25 A
FACTORS
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
Power of Reading
Table 25B
TESTS
S
P
1
2
3
4
5
6
7
8
9
10
.
54
TOTAL
Percent Contribution of Total Variance
Table 24
Total
Boys
Girls
Fast
Slow
Power
Non-Power
KNOWN-GROUPS

Figure 23.—Paradigm for analyses for comparing centroid factors in all known-groups.

Centroid Factor Structure of Speed of Reading

The loadings of Speed of Reading for each known-group on all identified factors are summarized in table 25, section A, which is tantamount to taking the first slice from the top of figure 23.

Boys vs. Girls

In general, the structure of Speed of Reading for boys and girls is remarkably similar. This is in essential agreement with the findings of Richardson's study (1949) of the sexes at grade V. However, the boys and girls in the present study do differ in the following respect: boys have a loading on the word-part analytic interest factor, whereas girls have a loading on academic school adjustment.

Table 25.—Loadings of Speed and Power of Reading for each known-group on each of the identified factors

Factor	Total	Boys	Girls	Fast	Slow	Powerful	Non-powerful
A. Speed of Reading							
Audiovisual verbal symbolic-reasoning	66	52	59	37	54	42	70
Personal problems	−06	−09	−03	07	−10	02	00
Sex-role interest	−07	−10	−13	16	−02	01	−08
Phonetic word-structure	17	21	31	17	19	43	03
Auditory perceptual	16	14	18	−00	09	10	03
Speed of visual-verbal perception	26	22	22	14	−05	09	−14
Systematization interest	06	−25	−24	06	11	−11	−16
Mechanical interest	−15						
Interest in things						00	19
Word-part analytic interest		13					
School adjustment (academic and/or social)			23			12	01
Communality (h^2)	60	51	65	23	47	40	57
B. Power of Reading							
Audiovisual verbal symbolic-reasoning	81	86	80	71	75	48	70
Personal problems	−01	−01	−04	−07	04	−08	09
Sex-role interest	−00	−00	03	−08	−02	00	−02
Phonetic word-structure	07	04	20	12	21	05	17
Auditory perceptual	26	19	28	−07	28	07	22
Speed of visual-verbal perception	16	12	20	29	04	26	16
Systematization interest	00	−02	−04	−10	−10	10	14
Mechanical interest	−01						
Interest in things						−09	14
Word-part analytic interest		02					
School adjustment (academic and/or social)			05			26	−08
Communality (h^2)	76	78	81	63	70	39	65

Fast vs. Slow

The most generalized statement that can be made for the fast and slow readers is that they show characteristic structural differences for Speed of Reading. To be specific, the fast have a lower loading than the slow on audiovisual verbal symbolic-reasoning. A positive loading exists for the fast, but a slightly negative one for the slow, on the sex-role interest factor. There is no relationship between Speed of Reading and the auditory perceptual factor for the fast group, but a slight positive one is evident for the slow group. The fast and slow groups have positive and negative loadings, respectively, on the speed of visual-verbal perception factor. The phonetic word-structure and systematization interest loadings are similar for the two groups.

Centroid Factor Structure of Power of Reading

The loadings of Power ot Reading for each known-group on all identified factors are summarized in table 25, section B. This is tantamount to taking the second slice from the top of figure 23.

Boys vs. Girls

In general, the structure of Power of Reading for boys and girls shows some important quantitative differences. Even though these two groups read with almost exactly the same power (no significant difference in their power scores), the boys have a higher loading on the audiovisual verbal symbolic-reasoning factor, while the girls have considerably higher loadings on phonetic word-structure, auditory perception, and speed of visual-verbal perception.

Powerful vs. Nonpowerful

The most generalized statement that can be made for the powerful and nonpowerful readers is that they show marked differences in the factor structure for Power of Reading. Most noticeable is the tremendous difference between the loadings for the two groups on the audiovisual verbal symbolic-reasoning factor. While both groups draw heavily upon Factor I, the nonpowerful readers utilize it to a greater degree than the powerful readers in order to *surmount within-group competition,* even though, of course, the powerful readers have, and use effectively, a great deal more than either the nonpowerful or intermediately powerful readers The basic differences in the modalities by which these two groups approach the Power of Reading task is dramatically illustrated in the auditory perception and speed of visual-verbal perception factors. Specifically, while the powerful group has a sizable loading only upon speed of visual-verbal perception factor, the nonpowerful group draws upon both, but with a greater emphasis on the auditory perceptual factor. This evidence, coupled with the fact that the nonpowerful group also uses, to a greater extent than the powerful group, the phonetic word structure factor, indicates that our nonpowerful readers at the high school level are in the transition stage of shifting from being auditory-bound word analyzers to verbal visualizers. That is, according to the gradient shift hypothesis of the Substrata-Factor Theory, it would be expected that beginning or retarded readers would have an auditory approach to the Power of Reading task, intermediate readers, a bimodal approach, and finally, mature readers an almost purely visual approach. The evidence just offered for the powerful and nonpowerful readers obviously supports the Theory. These high school nonpowerful readers are at the stage where they relate to the reading task in both auditory and visual modalities. The powerful readers, on the other hand, are already at the visual level. The present discovery supports the gradient shift hypothesis by building a bridge of fact where only a theoretical prediction had existed.

Finally, it should be noted that the loadings for Factor XI, school adjustment, are qualitatively different for the powerful and nonpowerful readers. That is, for the powerful readers, the loading of +0.26 represents *scholastic* adjustment and morale, whereas the loading of −0.08 for the nonpowerful readers appears to represent a low, but nevertheless, a kind of *social* adjustment[2] and morale. To put it another way, school adjustment and morale may be achieved through different routes: academic achievement and/or social service. The differential in attitudes found in these two groups may be related to their mobilizing mechanisms in Power of Reading. Conversely, these attitudes may also be the *outcome* of being a powerful or nonpowerful reader.

Summary of Centroid Factor Analyses of Total and Known-Groups

Eleven interpretable factors were identified, seven of which were common to all groups. In general, the factors extracted tend to be consistent with the hypothecated domains which were verified for the total group.

As in the total group, the main loadings of Speed and Power of Reading were on the audiovisual verbal symbolic-reasoning factor. The major difference between the fast and slow readers and between the powerful and nonpowerful readers was also found on this factor.

Boys and girls showed only minor differences on Speed of Reading. For Power of Reading, however, boys and girls were both found to rely heavily upon audiovisual verbal symbolic-reasoning, while girls relied relatively more on visual and auditory perception and phonetic word-structure.

These and other differences, quantitative and qualitative, tend to support the major hypothesis of the factor-analytic study of known-groups.

---

[2] The complete analyses presented in the official report substantiate this conclusion. Both groups had substantial loadings on School Adjustment and Morale. But the powerful group also had large loadings on Effective Study Plan, and Mechanics of Study, while the nonpowerful group had negative loadings on these factors. Finally, the powerful group had a high loading on scholarly values, whereas the nonpowerful group, in contrast, had a high loading on social service interest.

SECTION V

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

Chapter XIII. Summary, Conclusions, and Implications

Theory and Rationale of the Experiment

The Substrata-Factor Theory holds that general reading is a composite of Speed and Power of Reading and that underlying each component is a multiplicity of related and measurable factors. Further, the Theory states that, in essence, excellence in reading is normally an audiovisual verbal-processing skill of symbolic reasoning, sustained by the interfacilitation of an intricate hierarchy of substrata factors which are mobilized as a psychological working-system and pressed into service in accordance with the purposes of the reader.

The key concepts in the Theory, as outlined in chapter I, are (*a*) *substrata factors*, or closely related sets of information stored in neurological subsystems of cell-assemblies; (*b*) *audio-*, *visual-*, and *kinesthetic-modalities;* (*c*) *mobilizers* arising from the focusing of deep-seated value systems; (*d*) *interfacilitation* of substrata factors; (*e*) intracerebral communication, or *working-systems;* (*f*) nature, sequence, and scope of *information input;* (*g*) *associative conceptualization* stimulated by the cortical activity of *perception;* (*h*) *gradient shift* and its attendant alteration of the hierarchy of the working system; (*i*) *mutual-and-reciprocal causation;* and (*j*) *initial kick differential* with accrued amplification from monitored feedback which results in variation in output.

The following major and minor hypotheses derived from the Theory form the backbone of the present experiment:

1. The *major hypothesis* is that different known-groups will mobilize different substrata-factor hierarchies for the purpose of reading with Speed and/or Power; that is, there is more than one way to solve an intellectual problem.

2. The *minor hypothesis* is that, since a student can bring to focus in the reading process only those skills and abilities in his particular repertoire, he must learn to read by learning to *integrate* that characteristic hierarchy, or working-system, of substrata factors which will maximize the use of his strong abilities and minimize the use of his weak ones.

3. The ideal situation, of course, would be to test the above hypotheses on individuals. Since statistical limitations preclude making analyses on individuals per se, the experiment is based on the rationale that individuals who are alike on certain criteria can be placed into

known-groups. Such groups may then be statistically analyzed to obtain a best estimate of the pattern of abilities underlying Speed and/or Power of Reading in the theoretically most representative individual of each such known-group.

4. Therefore, this experiment is designed to further the investigation of the general Substrata-Factor Theory of Reading and to test the above hypotheses in the following known-groups at the high school level:

A. Total Sample
B. Boys vs. Girls
C. Bright vs. Dull
D. Fast vs. Slow Readers
E. Powerful vs. Nonpowerful Readers

5. Beyond the testing of the above hypotheses, there is expected to accrue from the study a body of precise and important information on the nature of the substrata factors which underlie the ability of high school students to read with Speed and Power.

Subjects

The 400 students in our sample were drawn at random from the total population of students attending the University of California Demonstration Secondary School during the summer of 1953.

The Tests and Their Reliability

The criteria tests, Speed and Power of Reading, were assessed on the Diagnostic Examination of Silent Reading Abilities, Part I and Part II. The reliability of each of these tests is 0.98 and 0.94, respectively.

The *Speed of Reading* test was constructed on the validity assumption that the faster a student can detect the use of an absurd word within a relatively simple paragraph, the faster is his rate of reading comprehension.

The *Power of Reading* test depends upon the ability of the student to grasp the central thought of a paragraph, note the clearly stated details, interpret the content of the paragraph, grasp an idea when it is dispersed through several sentences, and draw inferences from the ideas in the paragraph.

The 54 independent variables consisted of group-administered paper-and-pencil tests selected or constructed for the specific purpose of assessing those areas which the literature indicated might bear a meaningful relationship to the criteria. A great majority of these instruments had reliabilities in the .80's and .90's. These variables were grouped according to the following a priori categories:

Independent Variables

A. Mental Abilities
    1. Visual verbal meaning
    2. Spatial relations
    3. Inductive reasoning
    4. Word fluency
    5. Speed of addition
    6. Mechanical aptitude
    7. Verbal analogies
B. Linguistic Abilities
    8. Vocabulary in context
    9. Vocabulary in isolation
    10. Range of information
    11. Phonetic association
    12. Word sense
    13. Homonymic meaning
    14. Prefixes
    15. Suffixes
    16. Latin and Greek roots
    17. Visual spelling recognition
C. Verbal Perception
    18. Dot figure and ground
    19. Cue-symbol closure
    20. Word embedded
    21. Perception of reversals
D. Listening Comprehension
    22. Auding
E. Elements of Musical Ability
    23. Tonal memory
    24. Tone-quality
    25. Tone-intensity
    26. Tonal movement
    27. Tone-time interval
    28. Rhythm
    29. Pitch
    30. Musical taste
F. Academic Attitudes-Habits
    31. School adjustment and morale
    32. Scholarly values
    33. Mechanics of study
    34. Effective study plan
G. Interest
    35. Outdoor interest
    36. Mechanical interest
    37. Computational interest
    38. Science interest
    39. Persuasive interest
    40. Artistic interest

G. Interest—Continued
    41. Literary interest
    42. Musical interest
    43. Social service interest
    44. Clerical interest
H. Emotional-Social Problems
    45. School problems
    46. Postgraduation anxieties
    47. Problems with self
    48. Problems with others
    49. Home-family problems
    50. Boy-girl problems
    51. Health problems
    52. Things in general
I. Musicality
    53. Musical appreciation
J. Age
    54. Chronological Age

General Conclusions and Implications

1. *Major Premise of the Theory.* The evidence from both the substrata and centroid factor analyses for the total and all known-groups at the high school level converges to substantiate what was originally discovered at the college level by Holmes in 1948 and verified at the elementary level by Singer in 1960; namely, *that reading ability, in general, is a composite of Speed and Power, and that underlying each component is a multiplicity of related and measurable factors.*

2. *Major Hypothesis.* The evidence from the various centroid and substrata analyses on the known-groups support the correctness of the major hypothesis; namely, that there is more than one way to solve an intellectual problem, and that different known-groups may indeed mobilize a different set of subabilities in order to achieve identical success in their Speed and/or Power of Reading. The flowcharts summarizing the various substrata analyses show in detail just what differences exist in the factors mobilized by each of the known-groups in order to achieve Speed or Power of Reading.

3. *Minor Hypothesis.* As a general statement, the minor hypothesis was *not* substantiated; namely, that a student reads by integrating that characteristic hierarchy or working-system of substrata factors which will maximize the use of his strong abilities and minimize the use of his weak ones. From known-group to known-group, the accumulated evidence made it very clear just how this minor hypothesis should be modified in order to make it valid; namely, in order to be credited at all with Speed and/or Power of Reading at the high school level, a student must be able to mobilize minimum amounts of

certain basic audiovisual verbal reasoning abilities, even though these are among his weakest. However, as his proficiency increases, to surpass mounting competition, he must mobilize into his working-system increasing amounts of his appropriate strengths, even though such assets may be only remotely associated with reading success for people in general, and even though these strengths may be relative weaknesses for his known-group.

4. *The Foundation of Reading Ability.* The centroid and especially the substrata analyses for the total group have identified some fundamental abilities which underlie both Speed and Power of Reading. In tables 26 and 27, a synthesis of the centroid and substrata factors will be attempted.

From a correlation matrix a *centroid* factor analysis yields a number of factors, and a criterion such as Speed of Reading may have loadings on these factors. The square of a loading gives the amount which the factor in question explains in the variance of the criterion. In a *substrata* factor analysis, a set of primary factors is extracted, and beyond these, secondary and tertiary sets of factors may also be extracted.

Statistical Methodology of the Substrata-Factor Analysis

The Wherry-Doolittle-Holmes Substrata-Factor Analysis enables the investigator not only to select from a total battery the best team of tests for the prediction of a criterion, but also allows him to determine the substructural organization of the various elements underlying a particular criterion or subcriterion. In other words, while the Wherry-Doolittle selects the "best" team of tests for predicting a criterion at the first level, the substrata analysis allows the extraction of those preferential predictors at the second and third levels which best account for the distribution of individual differences in each of the substrata factors selected at the first level and similarly for succeeding levels. The process may be thought of as a derivative analysis which yields successive clusters of preferential predictors more and more remote from a major criterion.

By following the method [1] devised by Holmes in 1948, the contributions which the preferential predictors make through the primary, secondary, and tertiary factors to Speed and Power of Reading were calculated. These contributions constitute the amount of variance in the criterion that may be explained by any particular preferential element within any one of the substrata factors. Of course, there is no parallel to these specific values in the centroid method. This being the case, both types of factor analysis were performed on the same matrices.

---

[1] Example: On the right-hand side of the concentric chart for Power of Reading (fig. 25) at Level II, prefixes account for 7 percent of auding ability, and auding ability accounts for 16 percent of Power of Reading. By taking 7 percent of 16, one obtains 1.12 percent, the amount of variance in Power of Reading that can be attributed to prefixes working through auding ability. If we look in table 27 under the primary substrata factor auding ability, we find to the right of prefixes the figure 1.13 percent. This figure is more correct, inasmuch as it was calculated before the figures were rounded for the purpose of placing them on the Concentric Flowchart for Power.

Results

Substrata Analysis for Speed of Reading: Total Sample

The results of the substrata analysis for Speed of Reading are shown in figure 24. The concentric rings from the central target outward represent the hierarchical organization of the substrata factors discovered at *Levels I, II,* and *III* in the working-system for Speed of Reading. The disks contain the percent variance accounted for and should be summed over each of the preferential predictors active in any particular substrata factor's line of support.

At *Level 0,* on target, is Speed of Reading.

At *Level I,* auding, visual verbal meaning, inductive reasoning, homonymic meaning, and computational and literary interest are the primary substrata factors that together explain some 55 percent of individual differences in the speed with which high school students can read.

At *Level II,* in various combinations, verbal analogies, range of information, dot figure and ground, vocabulary in context, visual spelling recognition, word sense, Latin and Greek roots, prefixes, tonal movement, and spatial relations account, in terms of Speed of Reading, for individual differences in the primary factors.

At *Level III,* musical taste, school adjustment and morale, mechanical aptitude, cue-symbol closure, perception of reversals, vocabulary in isolation, phonetic association, suffixes, artistic interest, age, tone-quality, musicality, and tonal memory, all in various combinations, form lines of support which undergird the substrata factors discovered at the secondary level.

The following illustration may help in reading the chart. At *Level 0,* figure 24 shows that 55 percent (18+8+9+3+3+14) of Speed is accounted for by the following primary substrata factors: visual verbal meaning, inductive reasoning, homonymic meaning, computational interest, literary interest, and auding. The same logic holds for subsequent levels.

Substrata Analysis for Power of Reading: Total Sample

The concentric flowchart in figure 25 summarizes the results of the substrata analysis for Power of Reading. The *rationale* of the

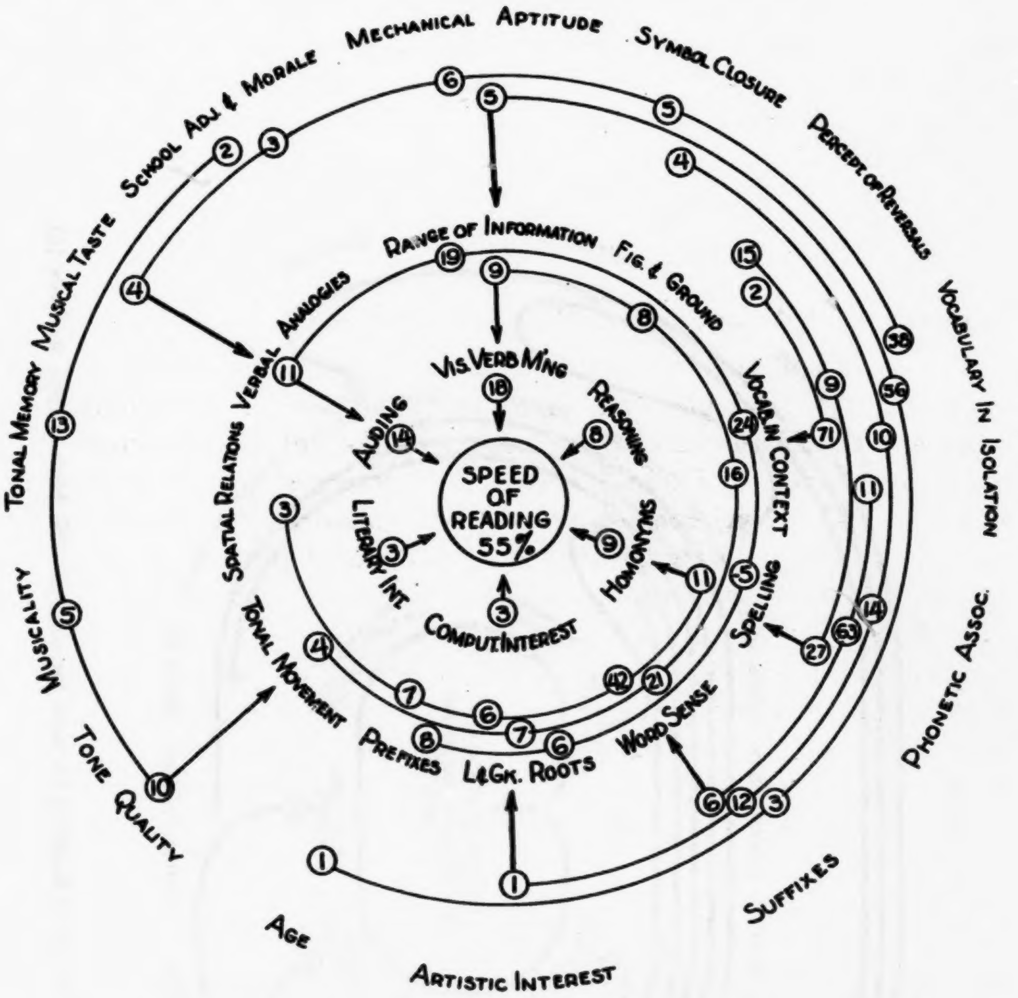

MECHANICAL APTITUDE
SYMBOL CLOSURE
PERCEPT. OF REVERSALS
VOCABULARY IN ISOLATION
PHONETIC ASSOC.
SUFFIXES
ARTISTIC INTEREST
AGE
TONE QUALITY
MUSICALITY
TONAL MEMORY
MUSICAL TASTE
SCHOOL ADJ. & MORALE
RANGE OF INFORMATION
FIG. & GROUND
VERBAL ANALOGIES
SPATIAL RELATIONS
VIS. VERB. M'NG
REASONING
AUDING
LITERARY INT.
HOMONYMS
COMPUT. INTEREST
VOCAB. IN CONTEXT
SPELLING
WORD SENSE
TONAL MOVEMENT
PREFIXES
L.&GK. ROOTS
SPEED OF READING 55%
6
5
5
4
2
3
4
13
5
10
1
1
19
9
8
15
2
9
71
38
56
10
11
14
63
27
3
6
12
11
18
14
8
3
9
3
24
16
11
5
3
4
7
6
7
6
8
42
21

Figure 24.—Concentric flowchart for Speed of Reading for total sample of 400 high school students (c).

substrata analysis may be traced in the lines of support which tie together the successive substructural elements undergirding the audio-visual and verbal-processing skills making up what we measure as Power of Reading. On each concentric line of support the percent contributions which the various substrata-factor systems make are designated, and the total variance accounted for is indicated within the arrowhead impinging on the particular substrata factor in the next inner area. Starting with Power of Reading at the center, it may be noted that—

At *Level I*, vocabulary in context, mechanical interest, effective study planning, visual verbal meaning, verbal analogies, auding, tone-intensity, and vocabulary in isolation together account for 75 percent of whatever it is that makes individual high school students differ in their ability to read with power.

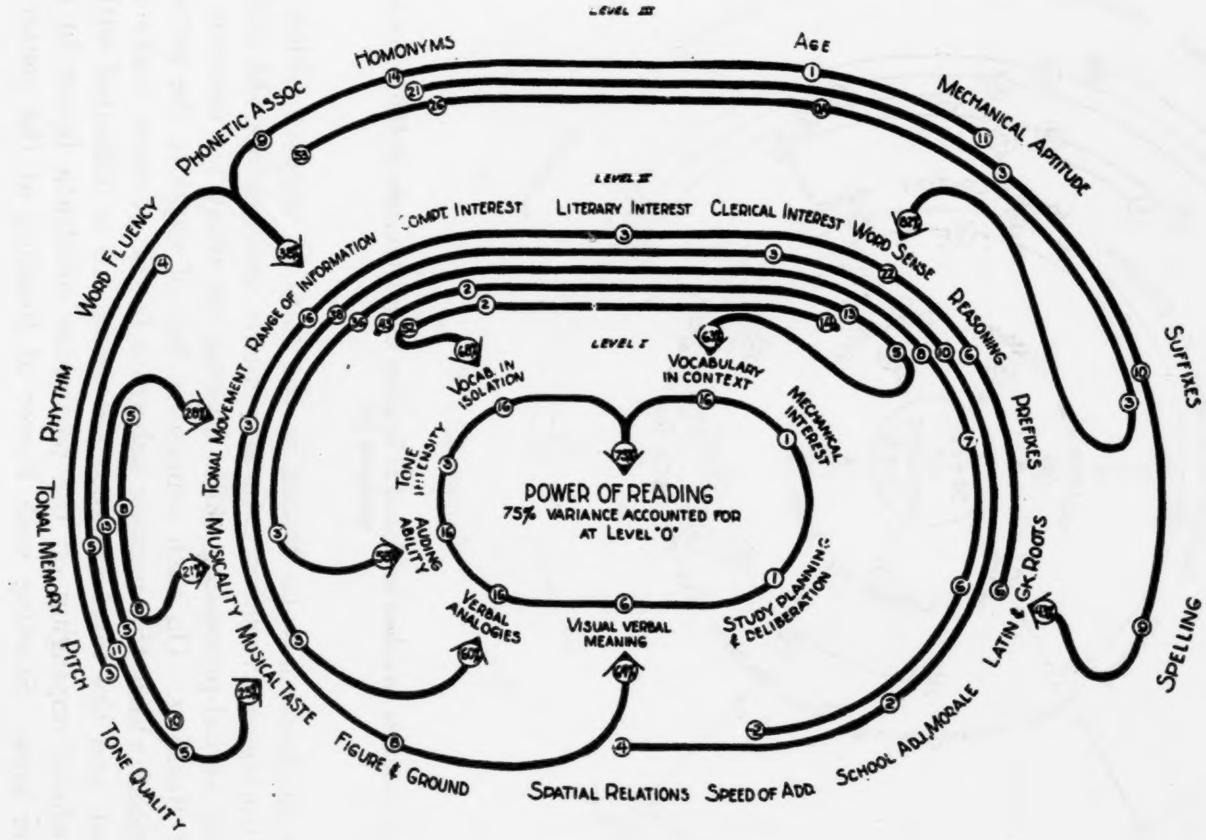

LEVEL III
HOMONYMS
AGE
MECHANICAL APTITUDE
PHONETIC ASSOC
WORD FLUENCY
RHYTHM
TONAL MEMORY
PITCH
TONE QUALITY
SUFFIXES
SPELLING
LEVEL II
COMPT. INTEREST
LITERARY INTEREST
CLERICAL INTEREST
WORD SENSE
REASONING
PREFIXES
LATIN & GK. ROOTS
SCHOOL ADJ. MORALE
SPEED OF ADD.
SPATIAL RELATIONS
FIGURE & GROUND
MUSICAL TASTE
MUSICALITY
TONAL MOVEMENT
RANGE OF INFORMATION
LEVEL I
VOCAB. IN ISOLATION
VOCABULARY IN CONTEXT
MECHANICAL INTEREST
STUDY PLANNING & DELIBERATION
VISUAL VERBAL MEANING
VERBAL ANALOGIES
AUDING ABILITY
TONE INTENSITY
POWER OF READING
75% VARIANCE ACCOUNTED FOR AT LEVEL "O"

Figure 25.—Concentric flowchart for Power of Reading for total sample of 400 high school students (c).

At *Level II*, likewise, by observing the specific contributions noted within the lines of support, it is evident that, in various combinations, the elements account for 63 percent of vocabulary in context, 64 percent of visual verbal meaning, 60 percent of verbal analogies, 58 percent of auding; and finally, it may be seen that word sense, computational interest, and range of information together account for 68 percent of vocabulary in isolation.

At *Level III*, it is evident that age, mechanical aptitude, suffixes, visual spelling recognition, tone-quality, pitch, tonal memory, rhythm, word fluency, phonetics, and homonymic meaning combine in various ways to account for the specified amount of the following secondary substrata factors: 82 percent of word sense, 43 percent of Latin and Greek roots, 25 percent of musical taste, 21 percent of musicality, 28 percent of tonal movement, and 38 percent of range of information. The particular elements that go to make up each of the separate substrata factors at *Levels I* and *II* may be determined by tracing the lines of support which undergird each.

Centroid Factor Analysis

As reported in chapter XI, a centroid factor analysis of the same correlation matrix for the total group (table 4) yielded eight centroid factors. A ninth factor could not be interpreted. These factors and the percent variance accounted for in the criteria are as follows:

Centroid factors	Percent	
	Speed	Power
I. Audiovisual verbal symbolic reasoning	43. 56	65. 61
II. Personal problems or maladjustment	. 36	. 01
III. Sex-role interest	. 49	. 00
IV. Phonetic word-structure	2. 89	. 49
V. Auditory-perceptual	2. 56	6. 76
VI. Speed of visual-verbal perception	6. 76	2. 56
VII. Systematization interest	. 36	. 00
VIII. Mechanical interest	2. 25	. 01
IX. Uninterpretable	. 81	. 09
Total	60. 04	75. 53

As may be seen from the above, the centroid analysis allows us to explain variance in Speed and Power of Reading in terms of these factors. However, the method does not enable us to determine the influence of any *particular* test variable within a factor on the criterion. It tells us only what the entire factor contributes.

Parsimonious as our list of eight factors is, it is well-recognized that on a *practical* level, such a list cannot be very useful to the teacher. One does not teach "audiovisual verbal symbolic-reasoning," "personal problems," etc., in relation to reading. The teacher *needs* to be given more specific instructions on how these general parameters of the mind may be constructed. Furthermore, on a *theoretical* level, many scientists consider the relative smallness of the unit-subsystems employed in the explanation of natural phenomena to be the hallmark of basic research.

In the light of the above theoretical and practical considerations, the substrata analysis appears to be a step in the right direction. Parallel to the factors isolated by the centroid analyses, the substrata analyses precipitated the following:

Primary substrata factors	*Percent speed*	*Primary substrata factors*	*Percent power*
I. Visual verbal meaning	17.9	I. Verbal analogies	16.2
II. Auding	13.5	II. Auding	15.9
III. Homonymic meaning	9.2	III. Vocabulary in context	15.9
IV. Inductive reasoning	8.3	IV. Vocabulary in isolation	15.7
V. Computational interest	2.9	V. Visual verbal meaning	6.0
VI. Literary interest	2.7	VI. Tone-intensity	3.2
		VII. Effective study plan	.9
Total	54.5	VIII. Mechanical interest	.8
		Total	74.6

Tables 26 and 27 integrate the substrata- and centroid-factor analyses. Reference to the bottom row of table 26 shows the percent contribution which each of the primary substrata factors makes to Speed of Reading. The extreme right-hand column gives the percent contribution which each of the particular preferential predictors makes to Speed of Reading. The cell entries from which these marginals are derived reveal the way in which the percent contribution made by each preferential predictor is distributed over the factors. By studying these cell entries and the marginals, the teacher and theorist may gain a better understanding of the qualitative and quantitative nature of the substrata factors underlying Speed of Reading. Furthermore, to highlight the essential relationships between the results obtained by the two methods, the contributions of the substrata factors are compared directly with the percent variance accounted for by the centroid factors listed in the left-hand margin of the table. Table 27 gives parallel information for Power of Readng.

A centroid analysis does not determine which components making up a centroid factor function to account for variance in a criterion. Tables 26 and 27, therefore, combine those preferential predictors which (*a*) had high loadings on a centroid factor, and (*b*) made significant contributions through a substrata factor to Speed and/or Power of Reading. Those variables which satisfied both criteria have been bracketed so that the relationships of the preferential predictors to both the substrata and centroid factors are apparent on inspection.

In tables 26 and 27 the evidence from the centroid and substrata factor analyses converges to summarize not only a precise body of information[2] on what factors undergird the ability to read with speed and power, but also how much each of the preferential predictors within the factors contributes to these criteria.

Figure 26 presents a three-dimensional model of the working-system of substrata factors mobilized by these high school students for the purpose of reading with power. The marginal entries from the right-hand column of table 27 are indicated on the spheres placed at the nodal points[3] within the appropriate level and factor on the model.

Implications

Steps have been taken in the monograph *toward* the integration of three different models (psychological, neurological, and statistical) of a new theory of how the mind works when confronted by a specific intellectual task, reading.

Reading is much more complex than is usually supposed. In the first place, it is a combination of speed and comprehension, and the subabilities needed vary according to which component is being stressed. In the second place, two individuals may read the same material with *equal* speed and comprehension by mobilizing quite different sets of neurophysiological, psycholinguistic, and audiovisual perceptual skills into a "working-system" marshaled to cope efficiently with the intellectual demands of the reading task. Finally, the composition of the working-system must change or shift as the child becomes an adolescent and later an adult.

It is now evident that *minimum* amounts of certain basic skills, such as command of vocabulary, range of information, and the ability to listen with comprehension, are absolutely necessary for any degree of success in reading, regardless of the method by which the child is taught. But beyond these basic abilities a student may draw upon such unlikely factors as mechanical aptitude or elements of musical ability in order to compete successfully with his peers in reading.

In addition, some interesting facts emerge from the comparative analyses of various groups. Even when there are no differences in the reading achievement or intelligence of the two groups, boys draw

---

[2] Statistically significant for the substrata analyses, at or better than the 1-percent level of confidence.

[3] Such nodal points represent substrata-factor abilities composed of multiple cell assemblies containing highly related and formally categorized information. This concept does not require that such cell-assemblies be concentrated in any particular area of the brain; all it represents is a subsystem having a relatively high integrity of its own.

Table 26.—Comparative distributions of variance in centroid and substrata factors accounting for Speed of Reading (N=400)

Centroid factors [2]		Preferential predictors	Primary substrata factors for Speed [1]						Total (percent)
Contribution to Speed	Percent		I Visual verbal meaning	II Auding	III Homonymic meaning	IV Reasoning	V Computational interest	VI Literary interest	
		Auding ability	------	5.03	------	------	------	------	5.03
		Range of information	0.56	.88	------	------	------	------	1.44
		Verbal analogies	------	.67	------	------	------	------	.67
		Vocabulary in context	.76	.86	------	------	------	------	1.62
		Vocabulary in isolation	3.48	4.35	0.55	------	------	------	8.38
		Literary interest	------	------	------	------	------	2.70	2.70
		School adjustment and morale	.01	.04	------	------	------	------	.05
I. Audiovisual verbal reasoning	43.56	Phonetic association	2.49	−.07	2.80	------	------	------	5.22
		Prefixes	------	1.01	.63	------	------	------	1.64
		Word sense	.75	------	.77	------	------	------	1.52
IV. Phonetic word-structure	2.89	Latin and Greek roots	.74	.46	.34	------	------	------	1.54
		Suffixes	.40	.17	.29	------	------	------	.86
		Homonymic meaning	------	------	2.87	------	------	------	2.87
		Visual spelling recognition	------	−.31	.51	------	------	------	.20
		Visual verbal meaning	6.45	------	------	------	------	------	6.45

VI. Speed of visual verbal		Dot figure and ground	1.36						1.36
meaning	6.76	Cue-symbol closure	.04	.10	.02				.16
		Perception of reversals	.07	−.01	.15				.21
		Spatial relations			.24				.24
		Reasoning				8.30			8.30
		Musical appreciation	.03						.03
		Musical taste		.05					.05
V. Auditory perception	2.56	Tonal movement	.46						.46
		Tonal memory	.09						.09
		Tone-quality	.07						.07
		Chronological age	.03	.03	.02				.08
VII. Systemization interest	.36	Artistic interest	.02	.01	.01				.04
		Computational interest					2.90		2.90
VIII. Mechanical interest	2.25	Mechanical aptitude	.09	.09					.18
		Mechanical interest		.14					.14
II, III, IX. Personal problems, sex-role interest, uninterpretable	1.66								
	60.04	Total for Speed	17.90	13.50	9.20	8.30	2.90	2.70	54.50

---

[1] See ch. VI.

[2] See ch. XI.

Table 27.—Comparative distributions of variance in centroid and substrata factors accounting for Power of Reading (N=400)

Centroid factors [2]		Preferential predictors	Primary substrata factors for Power [1]								Total (percent)
Contribution to Power	Percent		I Verbal analogies	II Auding	III Vocabulary in context	IV Vocabulary in isolation	V Visual verbal meaning	VI Tone-intensity	VII Effective study plan	VIII Mechanical interest	
		Auding ability	------	6.62	------	------	------	------	------	------	6.62
		Range of information	3.85	3.61	4.23	5.14	0.61	------	------	------	17.44
		Verbal analogies	6.54	------	------	------	------	------	------	------	6.54
		Vocabulary in context	------	------	5.80	------	------	------	------	------	5.80
		Vocabulary in isolation	------	------	------	5.05	------	------	------	------	5.05
I. Audiovisual verbal reasoning	65.61	Literary interest	------	------	------	------	.16	------	------	------	.16
		School adjustment and morale	.39	------	------	------	------	------	------	------	.39
		Phonetic association	.53	.50	1.72	1.88	.79	------	------	------	5.42
		Prefixes	------	1.13	------	------	------	------	------	------	1.13
		Word sense	------	------	.36	.37	.23	------	------	------	.96
IV. Phonetic word-structure	49	Latin and Greek roots	------	.52	------	------	.20	------	------	------	.72
		Suffixes	------	.09	.07	.07	.07	------	------	------	.30
		Homonymic meaning	.84	.98	1.47	1.69	.56	------	------	------	5.54
		Visual spelling recognition	------	.08	------	------	.03	------	------	------	.11
		Visual verbal meaning	------	------	------	------	2.19	------	------	------	2.19

VI. Speed of visual verbal meaning	2.56	Word fluency	.02								.02
		Dot figure and ground					.46				.46
		Spatial relations	.62								.62
		Reasoning	1.54	1.27	.84	.35					4.00
		Speed of addition		−.29							−.29
V. Auditory perception	6.76	Tone-intensity						3.20			3.20
		Pitch	.25	.23	.22	.27	.04				1.01
		Musical appreciation		.39							.39
		Musical taste	.36								.36
		Tonal movement					.14				.14
		Tonal memory	.02	.04			.02				.08
		Tone-quality	.02				.02				.04
		Rhythm		.02							.02
VII. Systemization interest	.00	Effective study plan							.90		.90
		Chronological age	.07	.07	.09	.11	.02				.36
VIII. Mechanical interest	.01	Computational interest			.38	.25					.63
		Mechanical aptitude	.65	.64	.72	.87	.11				2.99
		Mechanical interest								0.80	.80
II, III, IX. Personal problems, sex-role interest, uninterpretable	.10	Clerical interest	.50								.50
	75.53	Total for Power	16.20	15.90	15.90.	15.70	6.00	3.20	.90	.80	74.60

---

[1] See ch. VI.
[2] See ch. XI.

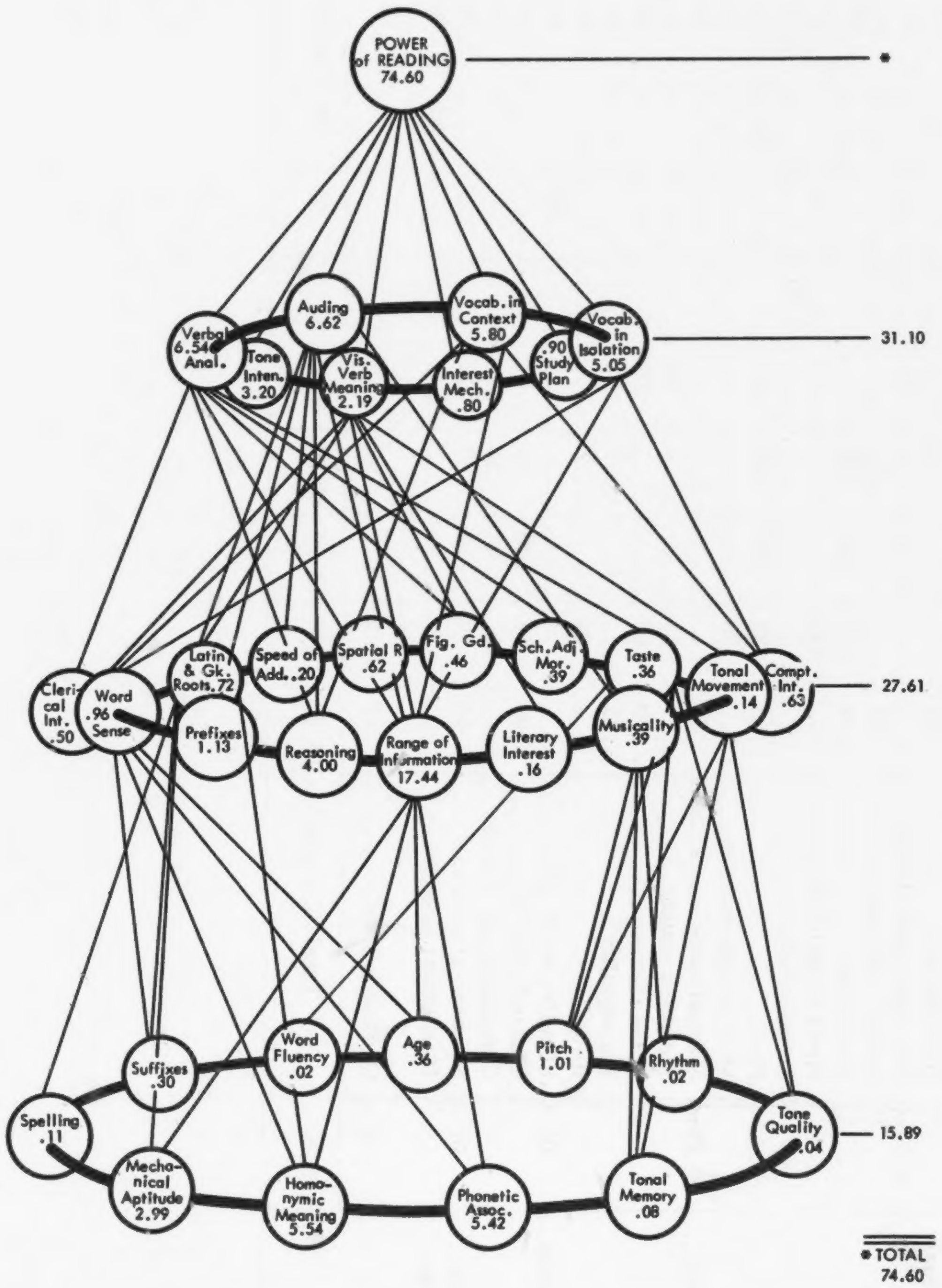

POWER of READING 74.60
*
Auding 6.62
Vocab. in Context 5.80
Verbal 6.54 Anal.
Tone Inten. 3.20
Vis. Verb Meaning 2.19
Interest Mech. .80
.90 Study Plan
Vocab. in Isolation 5.05
31.10
Latin & Gk. Roots .72
Speed of Add. .20
Spatial R .62
Fig. Gd. .46
Sch. Adj. Mor. .39
Taste .36
Cleri-cal Int. .50
Word .96 Sense
Prefixes 1.13
Reasoning 4.00
Range of Information 17.44
Literary Interest .16
Musicality .39
Tonal Movement .14
Compt. Int. .63
27.61
Suffixes .30
Word Fluency .02
Age .36
Pitch 1.01
Rhythm .02
Spelling .11
Tone Quality .04
15.89
Mecha-nical Aptitude 2.99
Homo-nymic Meaning 5.54
Phonetic Assoc. 5.42
Tonal Memory .08
* TOTAL 74.60

Figure 26.—Model illustrating umbellating nature of lines of support for substrata factors underlying Power of Reading at the high school level.

upon a different set of abilities than girls. More pronounced contrasts become evident when the fastest readers are compared with the slowest. For a different set of abilities must be acquired in order to improve the speed of an already fast reader from those needed to improve the speed of a slow reader. In the fast reader, mutual facilitation among the various subskills becomes so highly organized that rapid reading functions almost as a unitary ability. The slow reader is not only ill-equipped in specific substrata abilities, but his attack is more analytical, with loose organization and poor interfacilitation of the various substrata elements. Comparative analyses of the most powerful and least powerful readers provide still further confirmation of the major hypothesis of the Substrata-Factor Theory, for certain principles of visual perception were shown to be utilized by both these groups, but in quite different ways.

Perhaps the most significant findings for the teacher are those delineating the key abilities which underlie speed and power in the average reader—intelligence, perception of verbal relationships, range of general information, knowledge of words in isolation and in context, listening comprehension, phonetics, knowledge of prefixes and suffixes, ability to discriminate between words which look and sound alike but have different meanings, certain elements of musical ability, and others. The emphasis on linguistic factors suggests that teachers of English are in a strategic position to help a student reinforce his weak points, capitalize upon his assets, and learn to mobilize his whole range of skills for maximum efficiency.

Even the brightest students need to learn how to do these things, if they are to make the exceptional contributions indicated by their talents. The analyses of the brightest vs. dullest students in the sample prove that the bright rely heavily upon their main asset, rapid perception of verbal meanings, while the dull use a ponderous trial-and-error approach. In other words, the bright student reads a passage to extract the main ideas expressed by the author, but the dull student approaches it as an assignment in the mechanics of reading. Both groups, in reading to extend their range of information, must wrestle with the ideas expressed. But the dull student also has to struggle with the mechanical details of the reading process itself. In contrast, the bright student, in reading to learn, is not only extending his range of information, but at the same time is learning to read with greater speed and power. *For the evidence definitely shows that the greater the store of information, the easier the reading task becomes.* At some point the child must be taught a host of perceptual and linguistic skills if he is to learn to read. But for *power* especially, it is clear that, in order to give substance to his reasoning and increase his ability to learn through reading, he must continually build up a systematic body of information. In fact, the Theory and experiment suggest that building of such a body of knowledge is so important that every teacher, whatever his subject, should be considered a teacher of reading and should spend part of his time fostering the higher reading skills, especially in understanding the technical concepts and technical vocabulary peculiar to his own discipline.

In all, some 40 variables bearing on speed and power of reading, mostly the intellectual, linguistic, and audiovisual perception factors, were isolated. Other factors such as personality, home adjustment, social adjustment, and health made little contribution. But in terms of the Theory, the evidence from this and other studies (Holmes, 1959, 1961; Athey, 1965) suggests that the true relationship between reading and personality is to be found in the manner and intensity with which a person mobilizes his abilities to attain the aspirations and goals set up by his personal value system.

Because of the findings that the elements of musical ability are fundamental to the total reading process, one can no longer condone the notion that music training in the grades is a "frill" activity to be held apart from the "solid" subjects. Likewise, it must be stressed that mechanical training, so often relegated to those shop courses attended by the poorer academic students, also could profitably be utilized to develop the mechanical abilities in the very best students, since it is one of the unsuspected abilities which, in the end, make the difference between a fast reader and a very fast one. This discovery, in fact, may well support the new policy governing the curriculum in Soviet schools. We learn from Russian educators visiting this country that their school curriculums are being modified so that every student will soon spend part of each week through elementary and high school working in either industry or agriculture. The stated reason for this is that the hand is trained along with the mind, and that all intellectuals are given a firsthand acquaintance with the labor of the working man. Although this notion has been looked upon with some skepticism in the West, and the real purpose has been imputed by some Americans as a desire on the part of the Russians to increase the number of man-hours available to agriculture and industry (a view shared by the present writers), it now appears from the scientific evidence of the present study that an academic advantage may actually accrue when intellectually bright students have a chance to develop a basic understanding of mechanics. The same is true for music. At any rate, it may be concluded that shop courses at the elementary level, and perhaps even at the high school level, should not be relegated completely to the nonacademic sphere, but should be used in such a way as to strengthen the weaknesses of the naturally bookish type of person who will then not only be better trained in the coordinated use of the hand, the eye, and the brain, but also will be better equipped to read with speed than he otherwise would have been. Of course, such training could be easily overemphasized. What is indicated is a *sensible balance* between the academic and the mechanical types of training given to youngsters.

A further and most important implication is forced upon us by the impressive fact that while the analyses for the total group accounted for 75 percent of the variance in Power, only 55 percent of the variance in Speed of Reading could be "explained" by the substrata factors selected from our pool of 54 tests. Had the present study included eye-movement records so that the various measures of oculomotor efficiency would have been assessed also, it is quite possible (judging from the study at the college level by Holmes in 1948, 1953) that the total explainable variance for Speed could have been raised to 60 percent; but it is very unlikely that inclusion of such oculomotor measurements could have increased the variance beyond this figure. Therefore, the all-important question remains, what new variables can account for the other 40 percent of the variance in Speed of Reading?

It may be recalled that at the conclusion of his 1948 study, Holmes (1948, 1953) was able to account for no more then 56 percent of whatever it is that makes one college student different from another in his ability to read with speed. At that time, he hypothesized that much of the 44 percent unaccounted-for variance would be found in "motivational habit and desire for speed." In 1960, Holmes further detailed a more complete picture of the Substrata-Factor Theory of Reading. At that time he stressed the importance of the value systems in mobilizing one's substrata factors for Speed of Reading at a high-intensity level in order to *maximize the interfacilitation of the pertinent information held in the many neurological subsystems of the brain.*

In terms of Power of Reading, Holmes (1960) said, "*Other things being equal then, individual differences in the ability to reason about what is being read* (that is to manipulate mentally the inflow of new ideas so that they bear a meaningful relationship to what has already been learned) *depends both upon the essential nature of the stored information and the associative logic of the conceptualizing activity-of-perceptual processes stimulated within the brain by the meaningfulness of the sequential input of information at the time of presentation and reception,* i.e., reading input." In light of the present study, it is now clear that the *rate* at which the associative logic of conceptualizing takes place at the time of perception (reading input) is determined in a large measure (something less than 40 percent) by the limits of interfacilitation, the functional efficiency of the eyes, and supporting physiological subsystems (Davis, 1963).

The Substrata-Factor Theory of Reading therefore points unequivocally to the following hypotheses:

1. Beyond the level of content mastery of the information in the substrata factors themselves, a substantial proportion of the variance in Speed of Reading will be found in the *rate* at which functional interfacilitation in the working system can be maintained; i.e., retinal and mental processing time, Gilbert (1959).

2. From the Theory it can be predicted that, in order to maximize functional interfacilitation, tremendous internal forces must be mobilized in accordance with value systems which demand of the individual extraordinary excellence in reading speed. The attainment of such excellence, however, can only be accomplished during periods of persistent pressure and relentless drill in which the confident student strives to overreach his high level of aspiration. This "drive" for excellence is an attitude undergirded by value systems that place a high premium on the intellectual and efficient image.

3. A striking example of reciprocal causation is apparent in the way in which students learn to concentrate as a result of being placed under pressure during repeated speed drill. Many people complain that their speed is poor because they have difficulty in concentrating. But when conditions demand rapid reading with comprehension, concentration is an inevitable byproduct. The habit of striving to read rapidly for information then results in a habit-formation of concentration, which in turn makes for greater speed.

4. Enticing as the above hypotheses may be to the overzealous speed-reading teacher, it must be stressed that pushing children in this direction before they have mastered the fundamental substrata factors is to invite frustration and failure. Obviously, basic subabilities are necessary before one can hope to integrate them into an effective and efficient working system. However, once the optimum mastery of the substrata factors has been attained, a program to bring about maximum functional interfacilitation will, by the process of mutual feedback and reciprocal causation, step up the rate of information-input and the level of excellence of the separate substrata factors as well as the overall reading effort.

In brief, the study has made significant contributions in six important respects: (1) It has substantiated the major hypotheses of the Substrata-Factor Theory and established the validity of the claim that reading is an "audiovisual verbal processing-skill of symbolic reasoning;" (2) the large body of precise data on the factors underlying general reading ability will enable reading experts and elementary and high school teachers to determine which skills should be emphasized for a particular purpose; (3) the statistical techniques devised for the substrata analysis offer a powerful new tool for research in a number of areas; (4) the study points up some interesting relationships between substrata and traditional factor analysis; (5) new avenues of exploration have been opened up to persons interested in the teaching of English, in the education of the academically talented, and in the relationships between reading and a host of important but previously unsuspected factors; an finally (6) the study provides an explanation of the mechanisms by which extraordinary speed and superb power in comprehension of reading are obtained.

APPENDIXES

A. Discussion of Basic Assumptions

B. References

A. Discussion of Basic Assumptions[1]

The logic of sequentially prorating the variance accounted for in a criterion to the substrata factors undergirding it at lower and lower levels (see fig. 26, ch. XIII) rests upon two basic postulates. The first and perhaps most fundamental assumption of the Substrata-Factor Theory is that a substrata factor,[2] or any ability for that matter, is composed of a system of subsystems. Each subsystem itself is a composite of microsystems of cell-assemblies, conjoined with others to form larger systems which may be mobilized into a hierarchy of a more comprehensive working-system. The total cognitive complex of the brain is thought of as constituting a cosmos of subability systems which become dynamically associated in a multitude of working-systems in accordance with the requirements of the tasks and the purposes of the individual. Each of the substrata factor subsystems derives from the nature of its special information and rich associations a certain *functional integrity* of its own and at the same time may contribute to larger or more complex working-systems which have functional integrities of their own.

The second assumption is that a meaningful correlation in the present context merely reflects a mean mutual interaction of two sets of test scores which in turn represent the dynamic interplay of: (*a*) two macrosystems, (*b*) a system with one of its subsystems, or (*c*) two subsystems. It is an expression of a mutual and reciprocal relationship that, of course, need not be equal in both directions. In the Substrata-Factor Model, variance is an expression reflecting how people differ in an assessed ability; and correlation simply reflects the interdependence of two cortical systems. The new concept which the model introduces into psychometrics is this: When a standardized test is designed to assess varying degrees of an ability, ideally its items are selected in such a way as to representatively sample a domain of finite dimensions. Consequently, an array of scores on a particular test cannot legitimately be used to represent only the specific elements within the assessed domain. Large or small, a test score remains an integral function of the conjoined elements producing that score. Of course, an item analysis might attempt to identify items within a subdomain, but, in so doing, the identified items would no longer reflect the way in which they functioned within the larger domain. On the other hand, partial correlation retains the integrity of the subdomain assessed, i.e., the functional relationship of the variance accounted for, or unidirectionally, the degree of the effect of the subdomain on the larger domain.

---

[1] This discussion is a condensation of the paper delivered by the senior author before a joint meeting of the IRA and AERA at their annual convention in Philadelphia, May 1, 1964.

[2] In a correlation matrix derived from scores on a large pool of tests, there may be many abilities represented; but when by a substrata analysis a few of these are selected as making a significant and independent contribution to a criterion or subcriterion, they thereby become identified as substrata factors.

The two basic assumptions are consonant with the mathematical definition of a correlation (James and James, 1959) but make no appeal to the overlapping of identical or independent elements to explain correlation as did Spearman (1904) and Thomson (1919), respectively.

Both Thurstone (1947) and Hotelling (1933) were much too astute to explain the cause of correlations between abilities, or even the relationship of an ability to a factor or principal component in terms of the overlapping of identical elements. While neither man explicated his thoughts in this regard to the extent attempted by the present writer, Thurstone's first postulate certainly is in agreement with that of the Substrata Factor Model. He wrote:

> In factorial investigations of mentality, we proceed on the assumption that mind is structured somehow, that mind is not a patternless mosaic of an infinite number of elements without functional groupings . . . .
>
> Our work in the factorial study of the human mind rests on the assumption that mind represents a *dynamic system* which can eventually be understood in terms of a finite number of parameters. We have assumed further that all these parameters, or group of parameters, are not involved in the individual differences of every kind of mental task.
>
> Observational and educational experience lend plausibility to the conception that the mental *abilities* [such as reading] are determined by a great multiplicity of causes or determiners, and these determiners are more or less structured or linked in groups . . . . (Thurstone 1947, pp. 57–58; bracket inserted and italics added.)

Explanations of the variance of any particular domain's system in terms of subdomains to indicate the relative support which each draws from the other in accordance with X on Y or Y on X regression equations, or vice versa, may be used if, . . . and only if, the mutual and reciprocal cause-and-effect relationship can be justified on grounds other than the correlation coefficient per se. The Substrata-Factor Theory turns to neurological (Holmes 1957, 1961; Davis 1963), psychoeducational (Holmes 1948, 1953; Singer 1960), and psychometric evidence (Holmes 1954) to support the two basic assumptions given above (Holmes 1964).

In summary, for the Substrata-Factor Theory a test score is an integral function of a *total* cortical communications complex of preferential associations. The correlation, when the proper conditions obtain, reflects a structural and functional contraplex process in which two cortical systems act as if, and are assessed as if, their mutual and reciprocal cause and effect relationships arise from the interaction of two *organized* bodies of information. The prorating of variance accounted for in one by the other, then amounts to a quantitative apportionment of how one intact system affects another (Holmes 1964).

Theoretical constructs are manmade inventions designed to help comprehend a certain class of natural phenomena. As Thurstone put it, "A scientific law is not a part of nature. It is only a way of comprehending nature" (1947, p. 51). To the present writer there appears no antithesis between the classical factorial models as put forward by Thurstone (1947) and Hotelling (1933) and the Substrata-Factor Model. Likewise, there seems to be little or no redundancy in the two types of analyses; they simply "look at the data" from different vantage points in order to answer related but quite different questions.

B. References

Athey, Irene. *Reading-Personality Patterns at the Junior High School Level.* Unpublished doctoral dissertation, University of California, Berkeley, 1965.

Bennett, G. K., *and* Fry, Dinah E. *Test of Mechanical Comprehension, Form BB.* New York: Psychological Corporation, 1941.

Bower, E. M., *and* Holmes, J. A. "Emotional Factors and Academic Achievement," *Review of Educational Research,* 29: 529–544, 1959.

Caffrey, J. P. *California Auding Test, Form F.* Palo Alto, Calif.: California Council on Auding Research, 1952. (mineo.)

Carter, H. D. *The California Study Methods Test.* Berkeley, Calif.: Department of Educational Psychology, University of California, 1954. (mimeo) (Rev. Ed. published by California Test Bureau, Del Monte Research Park, Monterey, Calif., 1958.)

Conant, Margaret M. "The Construction of a Diagnostic Reading Test for Senior High School Students and College Freshmen," *Teachers College Contributions to Education,* No. 861, 1942.

Crook, Frances E. "Interrelationships Among a Group of Language Arts Tests," *Journal of Educational Research,* 51: 305–317, 1957.

Davis, F. B. "Two New Measures of Reading Ability," *Journal of Educational Psychology,* 33: 365–372, 1942.

Davis, Frank R. *Speed of Reading and Rate of Recovery in Certain Physiological Subsystems.* Unpublished doctoral dissertation, University of California, Berkeley, 1963.

Dvorak, A., *and* Van Wagenen, M. J. *Diagnostic Examination of Silent Reading Abilities: Junior Division; Part II, Form M.* Minneapolis: Educational Test Bureau, 1952.

Ezekiel, M. *Methods of Correlation Analysis.* New York: J. Wiley & Sons, 2d ed., 1953.

Feder, D. D. "Comprehension Maturity Tests: A New Technique in Mental Measurement," *Journal of Educational Psychology,* 29: 597–606, 1938.

Gans, Roma. A Study of Critical Reading Comprehension in the Intermediate Grades," *Teachers College Contributions to Education,* No. 811, 1940.

Garrett, H. E. *Statistics in Psychology and Education.* New York: Longmans, Green, 1947.

Gates, A. I. "An Experimental and Statistical Study of Reading and Reading Tests," *Journal of Educational Psychology,* 12: 303–314, 378–391, 445–464, 1921.

Gilbert, Luther C. "Speed of Processing Visual Stimuli and Its Relation to Reading." *Journal of Educational Psychology,* 50: 8–14, 1959.

——— *and* Holmes, J. A. "Reading: Psychology," *Review of Educational Research,* 25: 77–91, 1955.

Hall, W. E., *and* Robinson, F. P. "An Analytical Approach to the Study of Reading Skills," *Journal of Educational Psychology,* 36: 429–442, 1945.

Hebb, D. O. *The Organization of Behavior.* New York: J. Wiley & Sons, 1949.

Holmes, J. A. *Factors Underlying Major Reading Disabilities at the College Level.* Doctoral dissertation, University of California, Berkeley, 1948.

Holmes, J. A. *Diagnostic Examination of Visual Perception and Linguistic Abilities.* Berkeley, Calif.: The Author, 1953. Revised edition may be obtained from the Psychological Educational Services Association, Pebble Beach, Calif.

——— *The Substrata-Factor Theory of Reading.* Berkeley, Calif.: California Book Co., 1953.

——— "Factors Underlying Major Reading Disabilities at the College Level," *Genetic Psychology Monographs,* 49: 3–95 (first half), 1954.

——— "Increased Reliabilities, New Keys, and Norms for a Modified Kwalwasser-Dykema Test of Musical Aptitudes," *Journal of Genetic Psychology,* 85: 65–73, 1954.

——— "The Brain and the Reading Process," *Claremont College Reading Conference, Twenty-second Yearbook,* 49–67. Claremont, Calif.: Claremont College Curriculum Laboratory, 1957.

——— *and* Finley, C. J. "Under- and Over-age Grade Placements and School Achievement," *Journal of Educational Psychology,* 48: 447–456, 1957.

______ "The Substrata-Factor Theory of Reading: Some Experimental evidence," *New Frontiers in Reading,* Proceedings of the fifth annual conference of the International Reading Association, New York, N.Y., 1960.

——— "Personality and Spelling Ability," *University of California Publications in Education,* 12, No. 4: 213–292, 1959.

——— "Personality Characteristics of the Disabled Reader," *Journal of Developmental Reading,* 4: 111–122, 1961.

——— "Creativity and the Substrata-Factor Theory." Address before the American Association of School Administrators, San Francisco, February 1961.

——— "Basic Assumptions Underlying the Substrata-Factor Theory." Address before a joint meeting of the International Reading Teachers and the American Educational Research Association at their Annual Convention, Philadelphia, May 1964.

______ *and* Singer, H. "Theoretical Models and Trends Toward More Basic Research in Reading," *Review of Educational Research,* 34: 127–155, 1964.

______ *and* ______. *The Substrata-Factor Theory: Substrata Factor Differences Underlying Reading Ability in Known-Groups at the High School Level.* Final report covering Contracts No. 538 and 538A, U.S. Office of Education, U.S. Department of Health, Education, and Welfare, 1961.

Hotelling, Harold. "Analysis of a Complex of Statistical Variables into Principal Components," *Journal of Educational Psychology,* 24: 417–441, 498–520, 1933.

James, R., *and* James, R. C. *Mathematics Dictionary.* New York: Van Nostrand, 1959.

Johnson, D. M., *and* Reynolds, F. "A Factor Analysis of Verbal Ability," *Psychological Record,* 4: 183–195, 1941.

Kaiser, H. F. *The Varimax Method of Factor Analysis.* Unpublished doctoral dissertation, Universtiy of California, Berkeley, 1953.

Kelley, T. L. The Selection of Upper and Lower Groups for the Validation of Test Items. *Journal of Educational Psychology,* 30: 17–24, 1939.

——— *Fundamentals of Statistics.* Cambridge, Mass.: Harvard University Press, 1947.

Kling, Martin. *The Generalization of the Substrata-Factor Theory to General Open Systems Theory.* Unpublished doctoral dissertation, University of California, Berkeley, 1964.

Kuder, G. F. *Kuder Preference Record for Vocational Interest, Form CM.* Chicago: Science Research Associates, 1948.

Kyme, G. H. *Test of Musicality, The Value of Aesthetic Judgments in the Assessment of Musical Capacity.* Unpublished doctoral dissertation, University of California, Berkeley, 1954.

Langsam, Rosalind S. "A Factorial Analysis of Reading Ability," *Journal of Experimental Education,* 10: 57–63, 1941.

Lazar, May. *A Diagnostic Approach to the Reading Program,* Part I and Part II. New York City Board of Education, Bureau of Reference, Research, and Statistics, Education Research Bulletin, No. 3: 1–25; No. 4: 1–32, 1942.

Lubin, A. "Some Formulae for Use with Suppressor Variables," *Educational and Psychological Measurement,* 17: 286–96, 1957.

McNemar, Q. *Psychological Statistics.* New York: J. Wiley & Sons, 2d ed., 1955.

Maruyama, M. "Morphogenesis and Morphostasis," *Estratto Rivista Methodos,* 12: 1–46, 1960.

Michael, W. B. "Factor Analyses of Tests and Criteria: A Comparative Study of Two AAF Pilot Populations," *Psychological Monographs,* 63, No. 3 (whole No. 298), 1949.

Pressey, Luella W., *and* Pressey, S. L. "A Critical Study of the Concept of Silent Reading Ability," *Journal of Educational Psychology,* 12: 25–31, 1921.

Remmers, H. H., *and* Shimberg, B. *SRA Youth Inventory, Form A.* Chicago: Science Research Associates, 1949.

Richardson, J. *A Factorial Analysis of Reading Ability in Ten-Year-Old Primary School Children.* Unpublished master's thesis, University of Birmingham, England, 1949.

Singer, H. *Conceptual Ability in the Substrata-Factor Theory of Reading.* Unpublished doctoral dissertation, University of California, Berkeley, 1960.

Snedecor, G. W. *Statistical Methods,* Ames, Iowa: Iowa State University Press, 4th ed., 1946.

Spearman, C. "General Intelligence, Objectively Determined and Measured," *American Journal of Psychology,* 15, 201–293, 1904.

Thomson, Godfrey H. "The Hierarchy of Abilities," *British Journal of Psychology,* 9, 337–344, 1919.

Turstone, L. L. "Note on a Reanalysis of Davis' Reading Tests," *Psychometrika,* 11: 185–188, 1946.

——— *Multiple-Factor Analysis.* Chicago: University of Chicago Press, 1947.

——— *and* Thurstone, T. G. *SRA Primary Mental Abilities Test: Intermediate, Form AM.* Chicago: Science Research Associates, 1948.

Van Wagenen, M. J. *Diagnostic Examination of Silent Reading Abilities: Rate of Comprehension;* Part I, Form B., Junior Div. Minneapolis: Educational Test Bureau, 1953.

Wherry, R. J. "A New Formula for Predicting the Shrinkage of the Coefficient of Multiple Correlation," *Annals of Mathematics and Statistics,* 2: 440–457 1931.

——— "Test Selection and Supressor Variables," *Psychometrika,* 11: 239–247, 1946.

Wright, S. "Correlation and Causation: I. Method of Path Coefficients," *Journal of Agricultural Research,* 20: 557–585, 1921.

U.S. GOVERNMENT PRINTING OFFICE: 1966 O—777-593